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RESEARCH TRIANGLE INSTITUTE

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Contract Number N0022867C2297
OCD Work Unit Number 3233B
RTI Project Number OU-333

December 1969

FINAL REPORT

R-OU-333

Evaluation of Protection Achieved by Limited Strip Decontamination

(Part 2 of 2)

by

F. A. Bryan, Jr.
and
Richard Paddock

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SUMMARY

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Evaluation of Protection Achieved by Limited Strip Decontamination

Part 2 of 2

OCD Review Notice

This report has been reviewed in the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense

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for

Office of Civil Defense
Office of the Secretary of the Army
Washington, D. C. 20310

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SUMMARY

This report contains a summarization of studies undertaken to determine the protection achieved by limited strip decontamination. The work was aimed at investigation of urban area decontamination problems. The analyses have produced results which are capable of being incorporated in engineering calculations and in the formulation of decontamination guidelines.

A number of the studies pertinent to decontamination analyses were performed in support of the CONSTRIP V Program verification. Documentation of these results is contained in the first part of this final report and the results are referenced only briefly in the current volume.

Among the studies performed for evaluation of limited strip decontamination effectiveness and reported herein were studies of the effects of photon energy on gamma ray radiation penetration calculations and the effects of the changes in the fission spectrum as a function of time after fission product formation. Also studied were the relative importance of contaminated strips and of roof contamination in overall considerations of fallout decontamination. These studies are summarized in the report and further details are described in research memoranda referenced therein. The effects of source field shape on ground contribution were investigated as were the effects of using Engineering Manual calculations to predict ground contribution ignoring field shape per se.

A description is also given in this report of a survey of essential facilities in the Detroit area to determine common and special characteristics of the structures and their surroundings. Analyses were performed to determine decontamination effectiveness for components of these facilities and the results are summarized.

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December 1969

Approved by:

J. T. Wakeley, Director
Operations Research and Economics Division

F. A. Bryan, Jr.
Group Leader

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ABSTRACT

A discussion is given of analyses utilizing the CONSTRIP V Computer Program performed for the purpose of decontamination operation guideline development. The theoretical calculations are described in summary form and principal results are presented. Also included is a description of a survey of essential facilities in the Detroit area, with an accompanying analyses of these facilities to determine the effectiveness of limited strip decontamination operations.

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Evaluation of Protection Achieved by Limited Strip Decontamination

I. INTRODUCTION

Under a previous contract, effort was expended toward development of a computer program to calculate the reduction in dose rate achieved by the decontamination of limited strips of fallout. The basic calculational techniques used in this program were those incorporated in the CONSTRIP II Program, developed by the National Bureau of Standards. This previous contract work included making modifications to increase the flexibility and utility of CONSTRIP for the purpose of limited strip decontamination evaluation. This resulted in CONSTRIP III.[1/]

The objectives of the current research were to further increase the flexibility and utility of CONSTRIP in urban area decontamination effectiveness studies, and to apply this program in the development of operational procedures which might be used in decontamination of urban environments. In accordance with these objectives, research efforts have been directed toward two major areas. The first area included the improvement of the analysis techniques utilized in the CONSTRIP Program and verification of these techniques by comparison of calculated results with other theoretical and experimental data. The second major area of endeavor was aimed at investigation of urban area decontamination problems. The analyses in support of the latter effort have produced results which are capable of being incorporated in engineering calculations. Also in the latter area, a brief survey was made of essential facilities in the Detroit area to ascertain the common and special characteristics of buildings in urban areas. The results of these studies will be utilized in the future development of decontamination guidelines.

The following sections of this report summarize the studies which have been undertaken in this effort and give the principal results of those studies. Details of many of the individual studies have been reported in Part I of this final report. Other studies have been described in research memoranda written throughout the program of the research. These are summarized in the following sections. Still other studies, not previously reported, are given complete documentation in this report.

II. DISCUSSION OF RESEARCH

A. CONSTRIP V

As called for in the objectives of this research, and as described in the Scope of Work, Appendix A of this report, the CONSTRIP Program for the calculation of limited strip decontamination problems has been greatly improved with regard to its flexibility and utility in the solution of such problems. The starting point for the current work was the third generation of the program, CONSTRIP III. CONSTRIP III was developed under previous work on OCD Work Unit Number 3233B, and incorporated procedures originally developed by the National Bureau of Standards.[1/] CONSTRIP V, developed in the current research effort, has been described in Part I of this final report.[2/]

Since the CONSTRIP V Program description is available in other documentation, the following brief description is intended for those readers not desiring to peruse the detailed program description. This gives an idea of the program characteristics, its utility and its flexibility in solution of limited strip decontamination problems.

CONSTRIP V will calculate the penetration of radiation from a uniformly contaminated horizontal source area through a shielding wall to a point detector. Besides the capabilities of the predecessor, CONSTRIP III, CONSTRIP V has the capability of shielding calculations for walls with lower edges other than the level of the source plane. It incorporates an interpolation routine for operation on Monte Carlo data input to the program to produce data for wall thicknesses of other than those for which specific Monte Carlo calculations have been run. This allows calculations of dose angular distributions received by a point detector for arbitrary wall thicknesses. CONSTRIP V incorporates techniques for calculating dose rates at a detector behind a wall from sources characteristic of urban areas, including the effects of buildings shielding portions of the source field from the shielding wall. Additionally, calculations may be performed for photons of arbitrary source energy subject only to replacing the build-up factor currently supplied in the program for cobalt-60 with the appropriate build-up factor. The facility for

shielding calculations for photons of arbitrary source energy has been incorporated by including energy interpolation techniques in the program for application to Monte Carlo data of various energies. Interpolating Monte Carlo data for source energies of different energies also enables the program to do spectral calculations for arbitrary gamma source spectra, subject only to the availability of appropriate Monte Carlo input requirements and build-up factors as mentioned above.

The program has been checked against hand calculations and the output has been compared with experimental and other theoretical results for several representative problems. The results of the program are in good agreement with these other data and the program is believed to be a very significant improvement over previous techniques for solution of problems of barrier shielding against radiation from limited areas of decontamination.

Various studies concerning the effectiveness of limited strip decontamination have been undertaken using the CONSTRIP V Program. These are discussed briefly in the following sections.

1. Theoretical Calculations

Several comparisons have been made of the results of engineering calculations of the protection afforded by wall barriers against ground fallout contamination with the results obtained utilizing the CONSTRIP V Program. Additionally, comparisons have been made between the program results and the results obtained by other theoretical calculations and between the program calculated results and those given by experimental measurements.

The results of these various comparisons have been reported in various places. A number of the comparisons are given in the program verification section of the CONSTRIP V Program documentation,[2/] and others have been reported in various unpublished research memoranda which will be summarized below. In all cases, the results of the comparisons have been satisfactory, and CONSTRIP V has been found to be an accurate method of determining the dose received at a detector shielded from a limited area of fallout contamination of arbitrary shape through an intervening shielding barrier of arbitrary dimensions.

2. Photon Energies Used in Shielding Calculations

Since the present effort is primarily directed at determining the effectiveness of decontamination operations in a post nuclear attack situation, one question that immediately arises is what

Monte Carlo data should be utilized for these decontamination evaluations. It has been generally assumed that the cobalt-60 gamma radiation (average source energy, 1.25 MeV) closely approximates the radiation from fallout at 1.12 hours after fission product formation. However, the question arises whether in fact the increase in accuracy achieved by using ^{235}U fission product spectra at various times after fission product creation is warranted or whether other monoenergetic sources of photons should be used to simulate the later time spectra. In an effort to answer this question, a study was first undertaken to ascertain the average energy of gamma rays resulting from nuclear fallout at various times after creation of the fallout particles. This study, which has been reported in RTI Research Memorandum RM-333-1, Average Energy of Gamma Rays from Nuclear Fallout,[3/] resulted in a definition of the expected average energy of photons in a fission product deposition as a function of time after fission product creation. Spectral penetration calculations were made using several calculated[4/,5/,6/,7/] and one experimental determinations of the photon spectra[8/] arising from ^{235}U fission products (all unfractionated) as a function of time after product formation. The curves resulting from the calculations all have the same general shape (Fig. 1), with dips in average energy occurring at approximately 4 days and again at 1,000 days. Also, all of the curves show a general rise in the average photon energy between 5 and 30 days.

Spectral penetration calculations were performed utilizing the unfractionated ^{235}U fission product spectra of Nelms and Cooper.[5/] This work has been documented in a Research Memorandum, RM-333-6.[9/] These spectra were grouped about 5 energies for which Monte Carlo data were available (0.2, 0.4, 0.66, 1.25 and 5.0 MeV). These data, which were obtained from Berger, Eisenhauer and Morris,[10/] were used by the CONSTRIP Program to calculate dose rates to a detector through several different wall thicknesses. In order to keep the geometrical configurations simple, the problem assumed a concrete wall, 10 feet high by 40 feet long, located adjacent to a 40x40 foot field of contamination. The detector was assumed to be

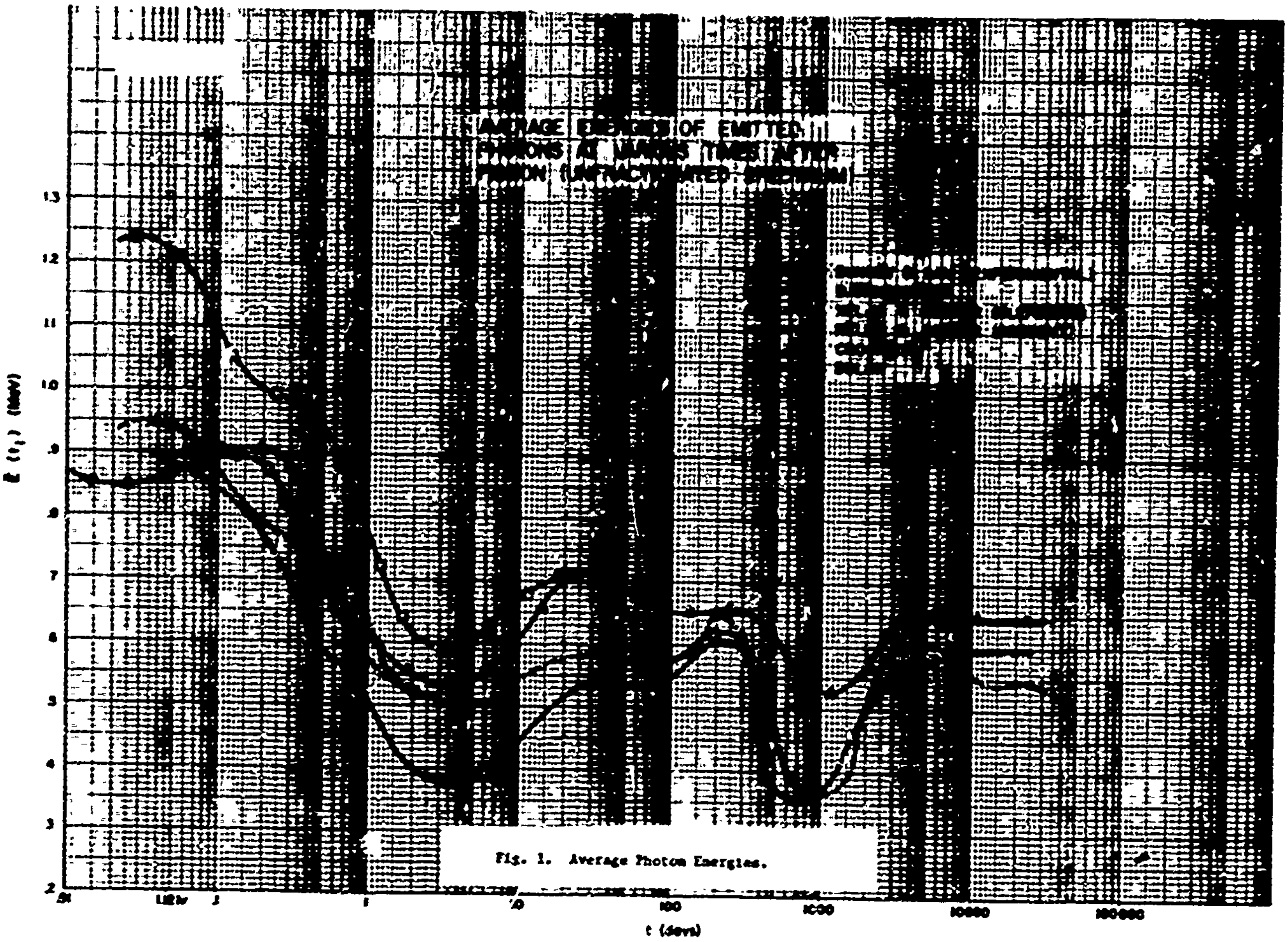


Fig. 1. Average Photon Energies.

at a height of 5 feet centered on the wall, and calculations were made for detector distances of 0, 5, and 10 feet behind the wall. Typical results of the calculations are given in Fig. 2 for the ground contribution (C_g) as a function of wall mass thickness X for a detector position 5 feet behind the center of the wall. For comparison the penetration from 1.25 MeV source photons is also indicated.

The most significant observation which may be made as a result of this study is that the 1.12 hour fallout spectrum seems to be justified as a basis for shielding calculations. As pointed out by Spencer[11/] -- "It turns out that the penetration properties of fallout gamma rays are less sensitive to spectral changes than might be supposed, except for very large penetration . . . ." Although the total contributions from the 21.1 and 45.3 day spectra are lower than that of the 1.12 hour fission product spectrum, the difference is not large enough to warrant separate treatment of the fission spectra for the various times after fission product formation. Therefore, this study indicates that shielding calculations for field decontamination operations are of sufficient accuracy when based upon the 1.12 hour ^{235}U fission product spectrum. The chief consideration for determining dose rates in an operational environment would be the activity of the source field at the time of interest.

3. <u>Partial Decontamination Effectiveness Studies</u>

It is probable that complete decontamination of a facility or group of facilities might not be feasible because of limitations in manpower equipment and supplies. Therefore, investigations have been conducted to determine the efficacy of partial decontamination operations. In these investigations, the principal objective was the determination of decontamination procedures that would give the greatest probable return on effort expended. Since the man-hours of effort involved in the particular operations are not explicitly considered in this research, the conclusions drawn from these studies are based upon the reduction in contribution or the increase in countermeasure factor achieved according to the decontamination fraction obtained over specified source areas.

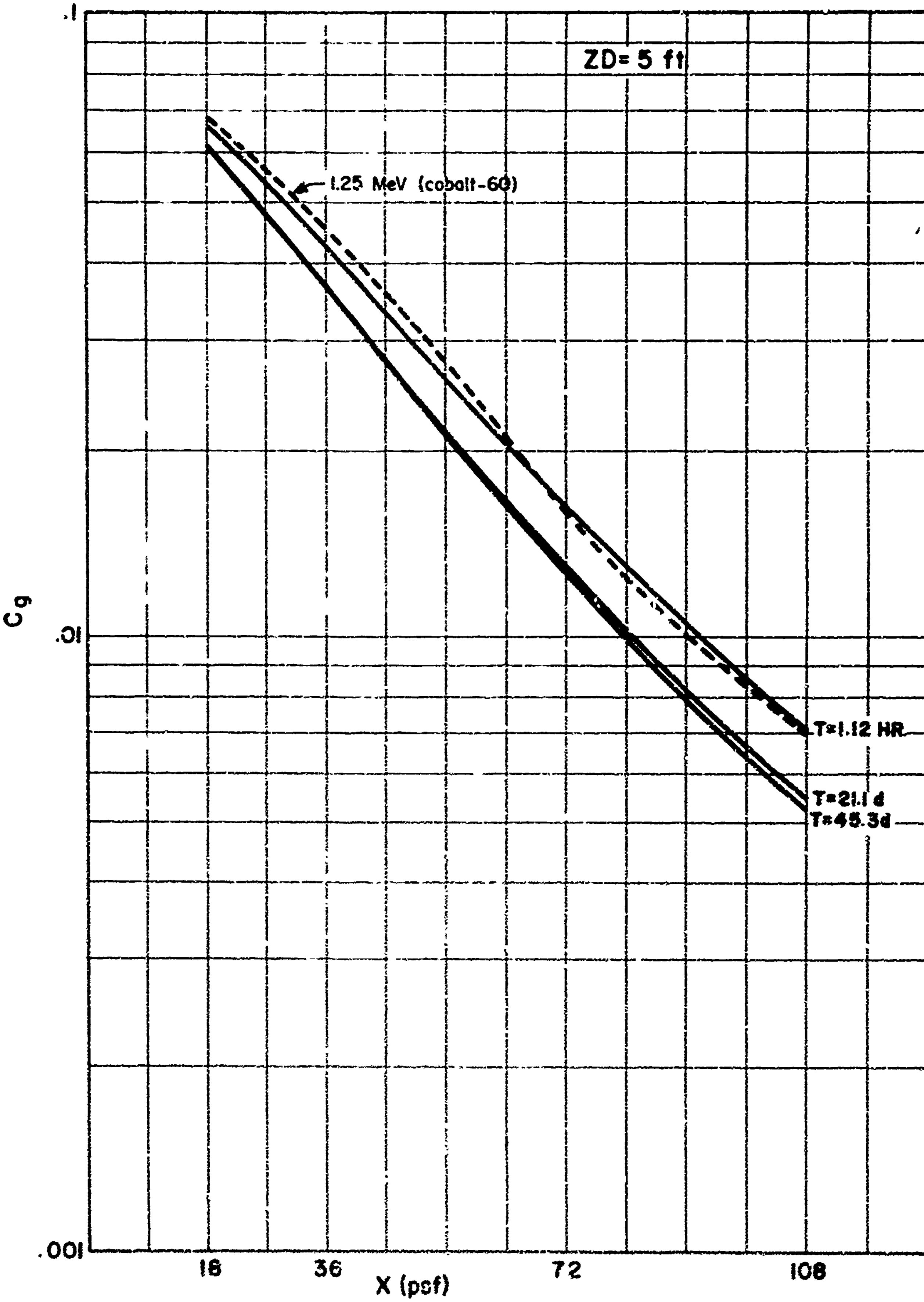


Fig. 2. Total Ground Contributions From Fallout at Various Times After Fission Product Formation.

a. Relative Importance of Contaminated Strips

In the first of these studies, reported in Research Memorandum RM-333-2, Relative Importance of Contaminated Strips,[12/] a simple, single-storied, unpartitioned building was assumed with dimensions of 150x200 feet with a building height of 30 feet adjacent a 200-foot square field of fallout contamination. This field was divided into eight 25-foot strips. Detectors were assumed to be located at the center of the building, at the wall, and halfway between these two points (Fig. 3).

Two methods of decontamination were considered. In the first, the contamination was assumed to be moved away from the shielding wall in a sequential strip-by-strip manner; that is, all of the contamination in strip two was moved to strip three, etc. In the second method, the contamination in a particular strip, or group of strips, was assumed to be removed completely out of harmful range. The contributions from the various 25-foot strips were calculated for detectors located at 50- and 100-foot distances from one end of the shielding wall. In all cases, the contributions to the various detector locations indicated that a greater dose rate would be received at a detector centered on the wall (100 feet from one end) than would be received at the 50-foot location. The fractional difference is nearly constant in all cases, however, and conclusions reached concerning the effectiveness of decontamination of various strips are the same for either detector location. The percentage of total contribution from the various strips is indicated in Table I for the detector centered on the shielding wall 3 feet above the contaminated plane, and behind walls of thicknesses 0.5, 1.0, and 2.0 mean free paths of cobalt-60 radiation.

The results of this study were also analyzed to determine the amount of decontamination required to obtain the counter-measure factor of 2 (i.e., the dose rate reduced to one-half its original value). Table II indicates the distance from the shielding wall that must be totally decontaminated to achieve this objective.

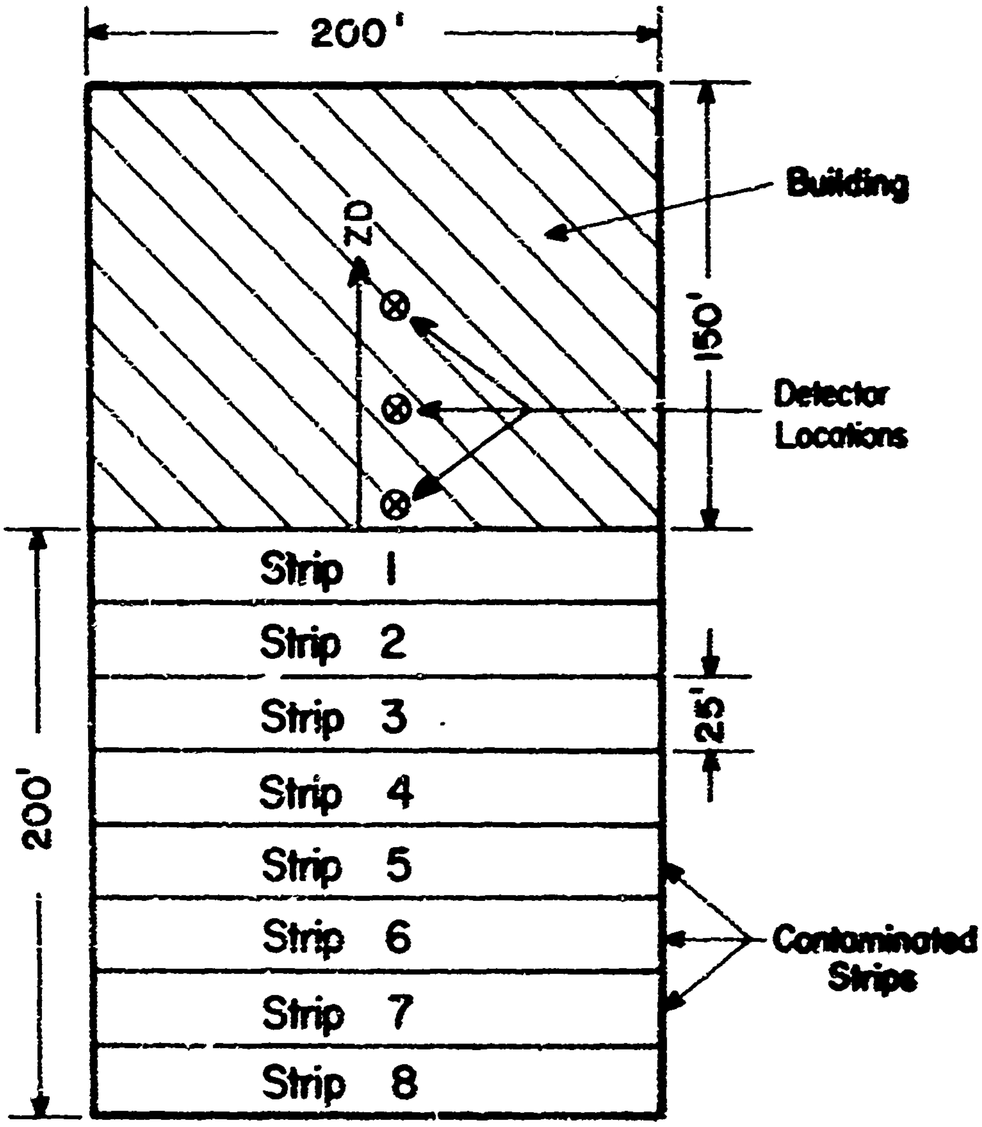


Fig. 3. Building and Contaminated Field.

Table I

PERCENTAGE OF TOTAL CONTRIBUTION FROM VARIOUS STRIPS

	Strip Number							
	1	2	3	4	5	6	7	8
T=0.5 mfp XD=0, YD=.1								
ZD = 0	61.2	16.3	8.3	5.1	3.4	2.4	1.8	1.4
ZD = 1.25	38.3	21.4	13.4	9.1	6.5	4.8	3.6	2.8
ZD = 2.5	32.4	20.7	14.3	10.3	7.7	5.9	4.7	3.7
T=1.00 mfp XD=0, YD=.1								
ZD = 0	56.7	17.5	9.3	5.9	4.0	2.9	2.1	1.6
ZD = 1.25	37.1	21.5	13.7	9.4	6.7	5.0	3.8	3.0
ZD = 2.5	32.2	21.0	14.4	10.4	7.7	5.9	4.7	3.7
T=2.00 mfp XD=0, YD=.1								
ZD = 0	50.8	19.0	10.5	6.9	4.8	3.5	2.6	2.0
ZD = 1.25	34.7	21.6	14.1	9.8	7.1	5.3	4.1	3.2
ZD - 2.5	31.0	21.3	14.6	10.6	7.9	6.1	4.8	3.8

Table II

AMOUNT OF CLEARING REQUIRED TO YIELD A COUNTERMEASURE FACTOR (CF) OF 2

	Distance from Wall (ft)	
	Moving to next strip	Removing entirely
T = 0.5 mfp		
ZD = 0 ft	37	18
ZD = 37.5 ft	80	37
ZD = 75 ft	105	43
T = 1.00 mfp		
ZD = 0 ft	40	19
ZD = 37.5 ft	90	40
ZD = 75 ft	110	47
T = 2.00 mfp		
ZD = 0 ft	54	25
ZD = 37.5 ft	93	40
ZD = 75 ft	110	47

(ZD is distance between detector and wall--The detector is centered on and three feet above the base of the wall.)

b. Effectiveness of Partial Decontamination

Another study which was conducted to determine the effectiveness of partial decontamination of the potential source field has been reported in Research Memorandum RM-333-5, Effectiveness of Partial Decontamination.[13] This study investigated the relative importance of three parameters: (1) source field position; (2) barrier thickness; and (3) detector position. A large rectangular source field was divided into square patches, and the CONSTRIP Program was utilized to calculate the contribution from each of these patches for several values of wall thickness and detector location. The results indicate that, while an increase in barrier thickness or detector distance from the wall naturally causes a decrease in contribution, at the detector location the difference is not nearly as great as that achieved by decontamination of a relatively small portion of the contaminated plane.

The geometry of the calculations is indicated in Fig. 4. For all of the detector positions considered, 70 to 80 percent of the dose contribution comes from 40 to 60 percent of the nearest source patches. For a detector adjacent to and centered on the wall, approximately half of the total contribution from the field comes from five of the nearest patches.

The contributions from these five patches, indicated in Fig. 4 as A, B, C, D, and E, are given in Table III for the detector on the mid-wall positions at a height of one-third the wall height. Again, the main conclusion to be reached from this study is that for a limited plane of contamination a substantial decrease in dose rate can be achieved by decontamination of a relatively small portion of the plane.

c. Effectiveness of Roof Decontamination

The arrival of radioactive fallout at a building location would result in the deposition of contamination on the roof of the building as well as on the surrounding ground. Therefore, a study was conducted to investigate the effectiveness of roof decontamination with respect to the overall contribution received at a detector location inside the building. For this study

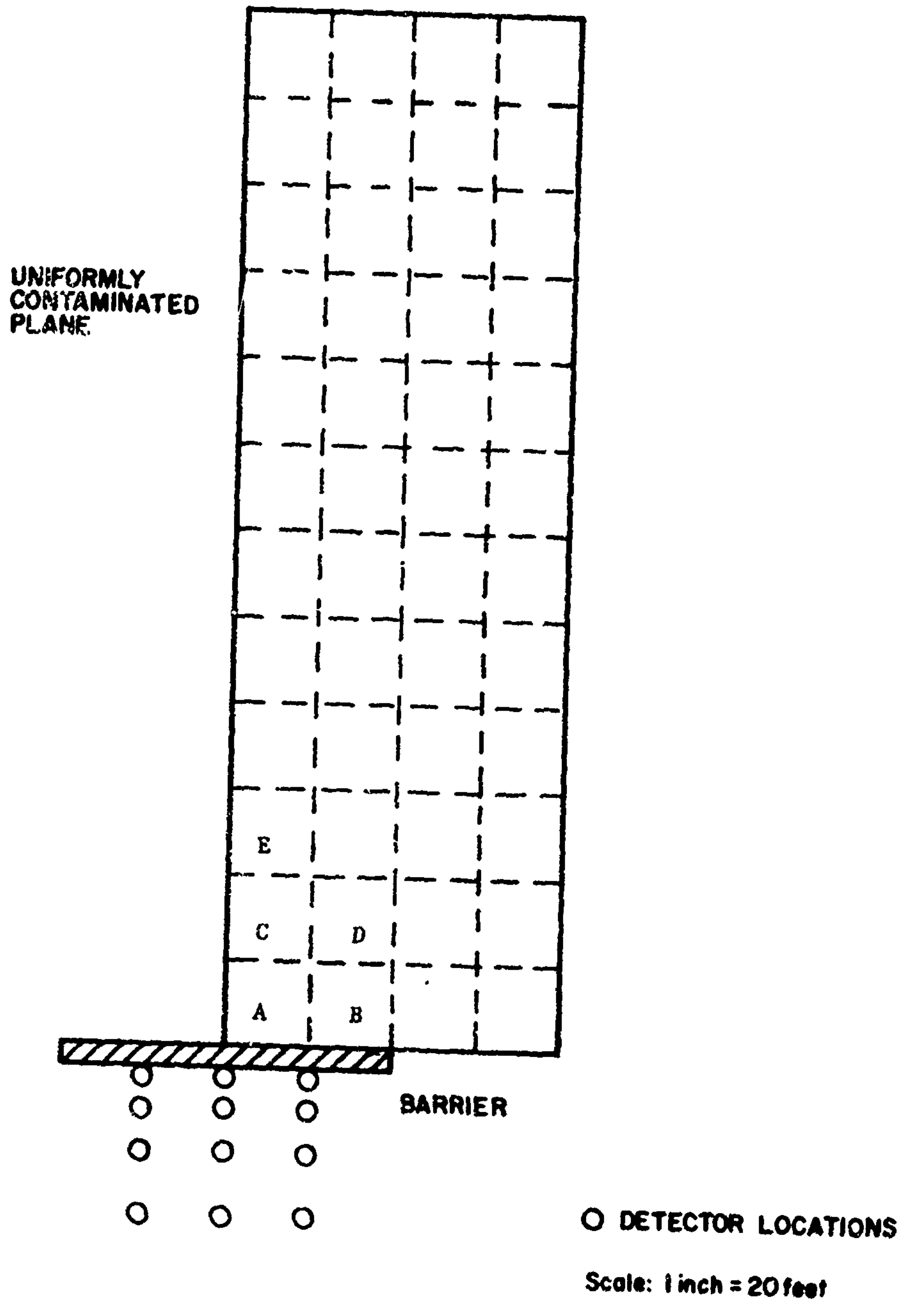


Fig. 4. Geometry of Partial Decontamination Calculations.

Table III

CONTRIBUTIONS FROM FIVE PATCHES, DETECTOR CENTERED

Wall Thick-ness (mfp)	Detec-tor Depth (feet)	Percent of Half-field Contributions from Patches					Sum of Percent Contributions			
		A	B	C	D	E	A + B	A + C	A+B+C	all 5
.25	0	38.71	5.95	11.18	5.66	4.43	44.66	49.89	55.84	65.92
.25	5	30.53	9.93	8.98	5.80	4.03	40.47	39.52	49.45	59.28
.25	10	21.88	11.14	8.27	6.08	4.18	33.02	30.15	41.29	51.56
.25	20	14.33	10.54	7.25	6.10	4.28	24.87	21.58	32.12	42.51
.5	0	37.15	4.77	12.46	5.95	4.73	41.92	49.61	54.38	65.06
.5	5	31.05	8.79	9.50	5.90	4.28	39.84	40.55	49.34	59.52
.5	10	22.36	10.57	8.61	6.15	4.34	32.93	30.97	41.54	52.03
.5	20	14.68	10.46	7.45	6.15	4.37	25.14	22.13	32.59	43.11
1	0	34.05	3.29	14.17	5.91	5.52	37.34	48.22	51.51	62.94
1	5	31.41	6.99	10.45	5.94	4.75	38.40	41.86	48.85	59.54
1	10	23.05	9.44	9.28	6.22	4.68	32.49	32.33	41.77	52.67
1	20	15.22	10.17	7.86	6.25	4.56	25.39	23.08	33.25	44.06
2	0	29.62	1.93	16.34	5.29	6.72	31.55	45.96	47.89	59.90
2	5	30.77	4.72	11.89	5.70	5.55	35.49	42.66	47.38	58.63
2	10	23.53	7.53	10.42	6.20	5.31	31.06	33.95	41.48	52.99
2	20	15.31	9.41	8.59	6.38	4.95	25.22	24.40	33.81	45.14
4	0	24.01	0.91	18.73	4.04	8.35	24.92	42.74	43.65	56.04
4	5	28.34	2.62	13.81	4.95	6.78	30.96	42.15	44.77	56.50
4	10	23.05	5.03	12.10	5.79	6.36	28.08	35.15	40.18	52.33
4	20	16.10	7.86	9.81	6.40	5.71	23.96	25.91	33.77	45.88
									Average:	54.28

three different building types were considered: a sample factory, a sample telephone company office building, and a sample warehouse. Overall dimensions were assigned arbitrarily; however, such factors as wall, floor, and roof thicknesses and compositions were determined from Boeckh's Manual for buildings of these types.[14] The details of the study are contained in the Research Memorandum RM-333-7, Effectiveness of Roof Decontamination.[15]

Three types of calculations were used for the study: CONSTRIP was used to calculate contributions from limited strips of contamination; infinite field contributions were calculated using the Engineering Manual Techniques;[16] and roof contributions were calculated by use of the PF-COMP Computer Program,[17] a program devised by RTI currently being used in the National Fallout Shelter Survey.

The study was designed to investigate: (1) whether a significant countermeasure factor inside a building could be obtained by hosing or sweeping the roof in such a manner as to allow the contamination to fall to the ground surrounding the building, and (2) the effect of incomplete decontamination of the building roof. The geometry of the problem is shown in Fig. 5. The results are summarized in Table IV. In each case considered, the contribution to a detector located at the center of the building was decreased by roof decontamination. However, the countermeasure factors achieved with roof decontamination were small in cases of buildings with thin walls. Also, the results indicate that the countermeasure factor is highly dependent on the decontamination fraction achieved on the building roofs. The only exception to this is a building with thin walls and fairly thick roof. For buildings with this type of construction, it may be possible to save effort in decontamination operations by ignoring the roof or by applying minimal effort to its decontamination. In general, however, roof decontamination must be considered of paramount importance for detector locations less than three stories below the roof.

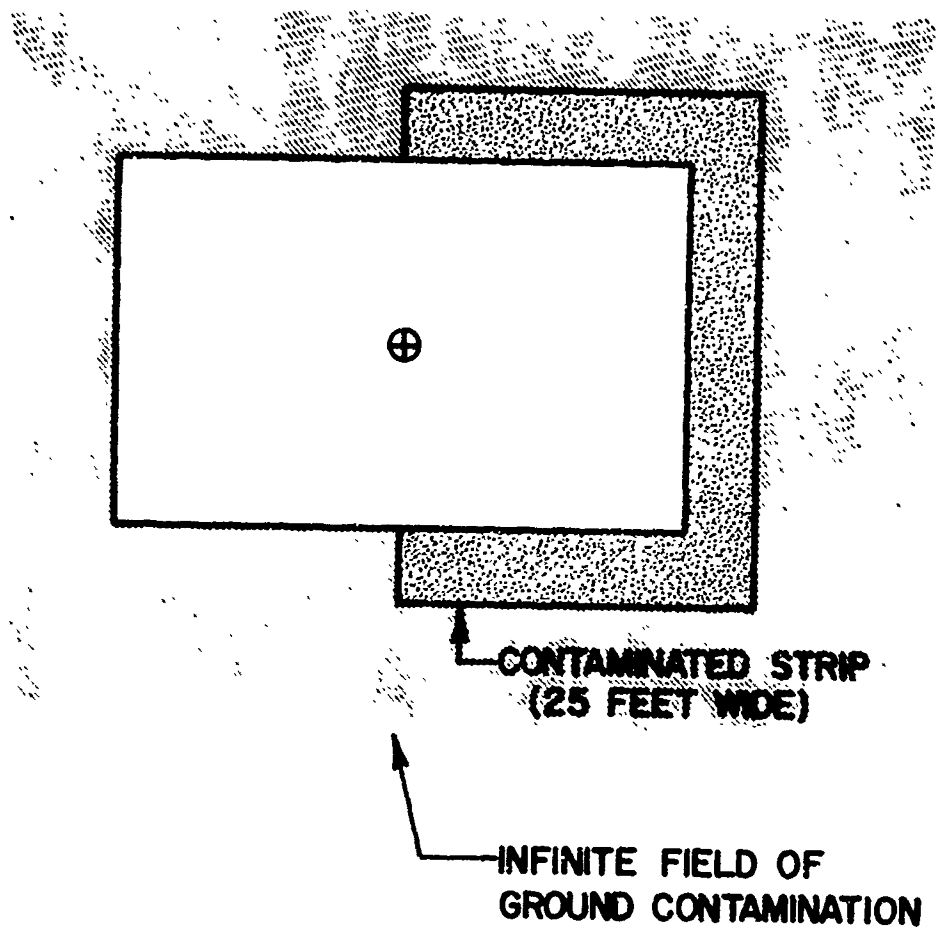


Fig. 5. Building After Roof Decontamination.

Table IV

Effectiveness of Roof Decontamination*

Building	Length (ft)	Width (ft)	No. of Stories	Building Height (ft)	Roof Mass Thickness (psf)	Floor Above Mass Thickness (psf)	Wall Weight (psf)	Roof DF†	CFΔ
Factory	300	200	1	30	29	None	18	0.0	1.16
								0.05	1.15
								0.1	1.14
								0.5	1.05
							36	0.0	1.69
								0.05	1.63
								0.1	1.57
								0.5	1.2
							72	0.0	2.36
								0.05	2.19
								0.1	2.05
								0.5	1.34
Telephone Office	100	75	2	20	54	50	108	0.0	1.39
								0.05	1.36
								0.1	1.34
								0.5	1.15
		(Detector on 2nd story)				None		0.0	3.64
								0.05	3.19
								0.1	2.83
								0.5	1.49
Warehouse	300	100	1	30	9	None	36	0.0	1.71
								0.5	1.65
								0.1	1.59
								0.5	1.22

* An infinite plate of ground contamination is assumed to surround the facilities; roof contaminant removed is assumed redistributed as shown in Figure 5.

† DF is the decontamination fraction; i.e., the fraction of fallout contaminant remaining after decontamination operations are complete.

Δ CF is the countermeasure factor; i.e., the ratio of the dose rate received at a detector location before taking protective action to that received after consummation of such action.

4. Source Field Shape Effects

The Engineering Manual calculational techniques use a modified barrier factor B_{ws} to compute the dose rate from a finite field received at a detector location due to radiation scattered in a shielding barrier. This barrier factor is assumed to depend only on the thickness (X) of the barrier and the solid angle fraction (ω) subtended by the source field at the mid-point of the shielding wall. Investigations made with the CONSTRIP Program (details of which are contained in Research Memorandum RM-333-4, Effect of Source Field Elongation on Radiation Received at a Detector[18/]) indicate that the elongation of the source field is important in determining dose rates. Field elongation, e_f, is defined as the field dimension perpendicular to the barrier, divided by the dimension parallel to the barrier (Fig. 6).

In this study, 200 cases were examined involving eight wall thicknesses ranging from 0 to 4 mean free paths of cobalt radiation (1 mfp = 36 psf), 5 solid angle fractions ranging from 0.01 to 0.3, and 5 values of e_f ranging from 0.25 to 4.0. Contributions to a detector adjacent to a wall were calculated for all 200 cases and values of the ground contribution (C_g) as a function of e_f were plotted for constant values of barrier thickness and solid angle fraction. In several cases, there was more than a ten fold increase in C_g as e_f was varied from 0.25 to 4.0. The results of this study are given in Table V. Figure 7 shows curves typical of limited contaminated planes of the total ground contribution received through barriers of various thicknesses as a function of field elongation. For purposes of comparison, the results utilizing engineering manual techniques are shown as dashed lines. These results indicate the importance of field elongation as a parameter to be considered in engineering calculations of limited strip contamination problems.

In order to gain an idea of the magnitude of variation in B_{ws} as a function of e_f, B_{ws} values were obtained by substituting the CONSTRIP calculated values of C_g due to wall scattered radiation into the appropriate engineering manual expression and solving for B_{ws}. In some

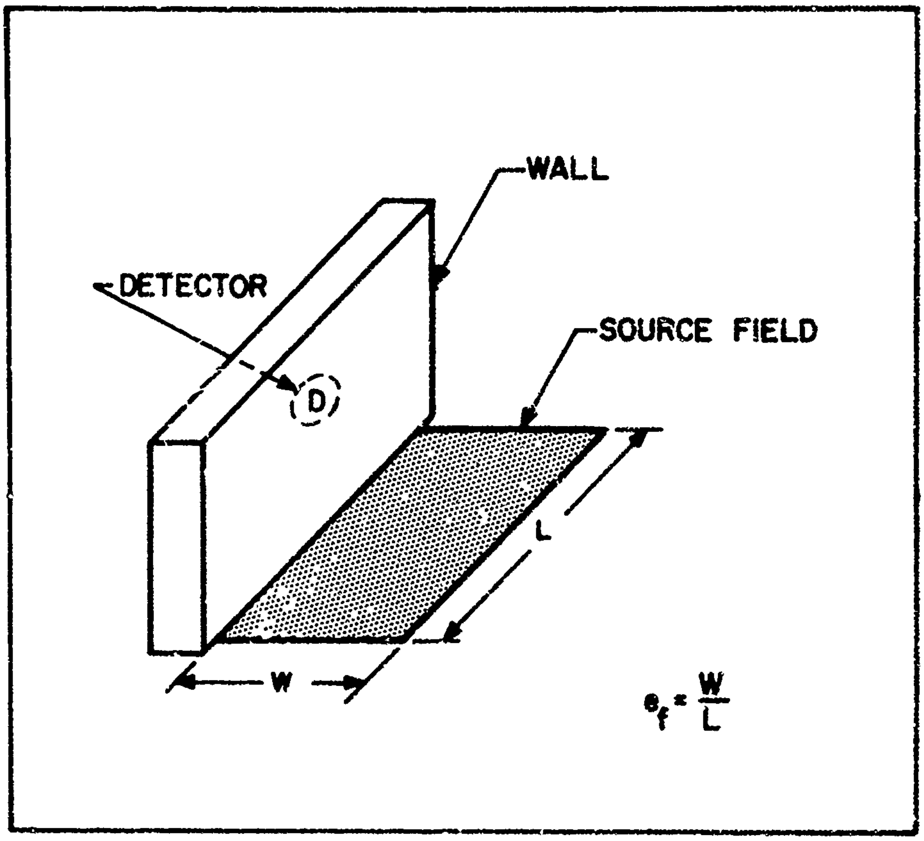


Fig. 6. Geometric Configuration.

Table V

EFFECT OF SOURCE FIELD ELONGATION ON CONTRIBUTION*

X_e (mfp)	e_f	Contribution (ω=0.01)	(ω=0.05)	(ω=0.1)	(ω=0.2)	(ω=0.3)
0	0.25	19.6171(-4)	99.6682(-4)	20.9714(-3)	48.5146(-3)	86.9305(-3)
	0.5	19.5641(-4)	96.7784(-4)	20.5270(-3)	47.0503(-3)	84.3705(-3)
	1.0	19.6176(-4)	97.8999(-4)	20.9485(-3)	48.4433(-3)	86.8007(-3)
	2.0	19.8012(-4)	10.1748(-3)	22.2704(-3)	52.0150(-3)	92.1216(-3)
	4.0	20.2070(-4)	10.9124(-3)	24.2959(-3)	55.9505(-3)	97.1222(-3)
0.25	0.25	14.8790(-5)	25.7620(-4)	7[illegible].8975(-4)	24.3688(-3)	51.5199(-3)
	0.5	27.0892(-5)	34.6989(-4)	96.7587(-4)	27.2895(-3)	54.0715(-3)
	1.0	44.0775(-5)	45.4338(-4)	11.8524(-3)	31.4384(-3)	59.5630(-3)
	2.0	64.8846(-5)	57.1999(-4)	14.3063(-3)	36.1368(-3)	66.4225(-3)
	4.0	88.0725(-5)	69.9164(-4)	16.8000(-3)	40.7979(-3)	74.4933(-3)
0.5	0.25	46.7676(-6)	11.0171(-4)	40.8000(-4)	15.2227(-3)	34.9380(-3)
	0.5	91.2083(-6)	16.6316(-4)	57.9721(-4)	18.6453(-3)	39.2532(-3)
	1.0	17.7084(-5)	26.9519(-4)	79.2736(-4)	23.0688(-3)	45.4117(-3)
	2.0	31.3863(-5)	38.0780(-4)	10.4157(-3)	27.7554(-3)	51.4993(-3)
	4.0	50.3183(-5)	50.8091(-4)	12.8729(-3)	31.6540(-3)	57.5875(-3)
0.75	0.25	24.4805(-6)	55.5787(-5)	23.2588(-4)	10.1461(-3)	25.0740(-3)
	0.5	44.1876(-6)	98.6600(-5)	37.0193(-4)	13.2598(-3)	29.3634(-3)
	1.0	87.0791(-6)	17.0589(-4)	55.5755(-4)	16.3263(-3)	35.0233(-3)
	2.0	16.9880(-5)	26.6022(-4)	77.8098(-4)	21.5261(-3)	40.4479(-3)
	4.0	30.8034(-5)	37.9067(-4)	99.6086(-4)	24.9046(-3)	44.7962(-3)
1.0	0.25	14.6723(-6)	30.8635(-5)	13.9003(-4)	68.7666(-4)	18.3011(-3)
	0.5	25.0629(-6)	58.0974(-5)	24.0928(-4)	95.3265(-4)	22.2301(-3)
	1.0	48.0986(-6)	11.0210(-4)	39.4377(-4)	13.1772(-3)	27.5133(-3)
	2.0	97.6893(-6)	18.8332(-4)	58.7792(-4)	16.0231(-3)	32.5397(-3)
	4.0	19.4054(-5)	28.5938(-4)	78.5370(-4)	20.1033(-3)	36.0321(-3)
2.0	0.25	35.9992(-7)	63.6384(-6)	28.3793(-5)	17.4895(-4)	57.7304(-4)
	0.5	58.0491(-7)	11.7692(-5)	55.3805(-5)	28.4048(-4)	77.3948(-4)
	1.0	10.0706(-6)	24.9365(-5)	11.2156(-4)	46.3767(-4)	10.6451(-3)
	2.0	19.7612(-6)	53.0554(-5)	20.3054(-4)	67.0821(-4)	13.4635(-3)
	4.0	41.9164(-6)	98.3533(-5)	30.7038(-4)	84.0980(-4)	15.4150(-3)
3.0	0.25	91.7934(-8)	16.1964(-6)	72.9213(-6)	48.6825(-5)	18.8353(-4)
	0.5	15.0868(-7)	30.1425(-6)	14.7603(-5)	84.6641(-5)	27.1627(-4)
	1.0	25.9081(-7)	66.1301(-6)	33.3650(-5)	16.3559(-4)	40.8400(-4)
	2.0	50.1460(-7)	15.6723(-5)	70.4034(-5)	26.1480(-4)	54.8136(-4)
	4.0	10.9821(-6)	33.9760(-5)	11.8829(-4)	34.5732(-4)	64.7780(-4)
4.0	0.25	22.3804(-8)	42.8932(-7)	20.2746(-6)	14.7035(-5)	65.4395(-5)
	0.5	36.1654(-8)	83.2742(-7)	43.6473(-6)	28.7998(-5)	10.0438(-4)
	1.0	65.5797(-8)	19.4464(-6)	10.5394(-5)	60.5605(-5)	16.2536(-4)
	2.0	13.8351(-7)	48.9857(-6)	25.6838(-5)	10.5393(-4)	22.7919(-4)
	4.0	31.5477(-7)	12.3540(-5)	47.6471(-5)	14.4807(-4)	27.4783(-4)

* (Number in parentheses indicates exponent of 10)

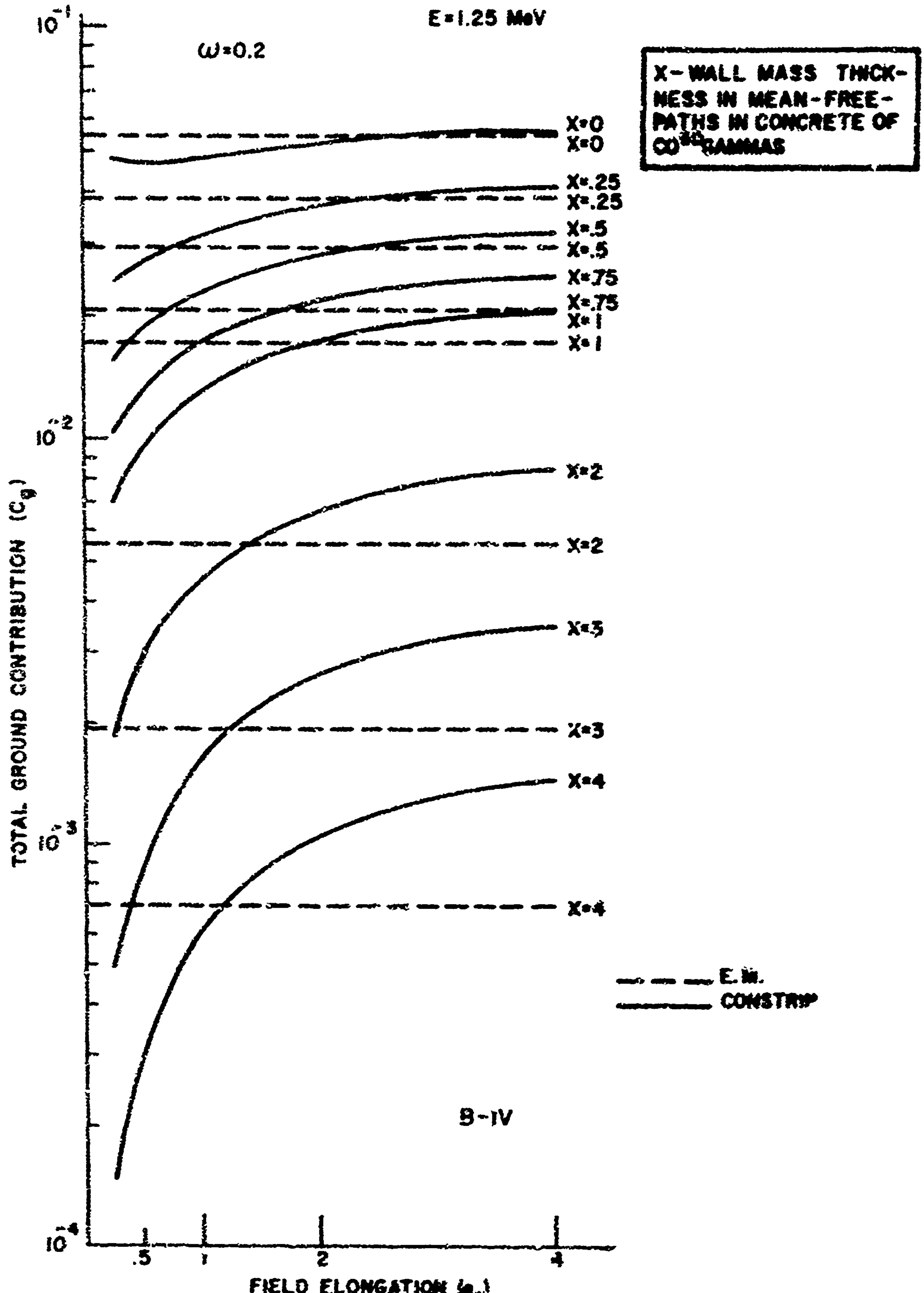


Fig. 7. Ground Contribution for ω of 0.2 as a Function of Field Elongation.

cases the values of B_{ws} were changed by a factor of ten throughout the range of the field elongations. A sample of these results is given in Fig. 8.

The main conclusion to be reached from this study is that some type of revision should be made to the engineering manual charts to include the source field elongation parameter.

5. Other Comparisons with Engineering Calculations

In Research Memorandum RM-333-2, Relative Importance of Contaminated Strips,[12] the dose rates to a detector from various 25-foot strips of contamination were calculated by the CONSTRIP Program. These calculations were performed for three different wall thicknesses and six different detector locations (see Fig. 3). For purposes of comparison, these same calculations were made using Engineering Manual techniques. Input parameters for the calculations were as follows:

a) Source energy: 1.25 MeV

b) Wall thickness: 18, 36, 72 psf (0.5, 1.0, 2.0 mfp of cobalt-60 photons)

c) Wall height: 30 feet

d) Source field: 200x200 feet, divided into eight 25-foot strips (for CONSTRIP);

$L + 2\ W_c$, W_c = 200 feet (for Engineering Manual)

e) Wall length: 200 feet

f) Detector height: 3 feet

Since Engineering Manual[16] methods are based on a detector located in the center of the building, the building width was varied so as to let the detector be located at 0, 37.5 and 75 feet back from the wall (but centered on the wall length in all cases). The wall-scatter barrier factor, B_{ws}, was obtained by calculating ω_s from mid-wall height, and contributions from individual strips were obtained by the process of differencing.

The results of both the Engineering Manual and CONSTRIP calculations are shown in Table VI for wall-to-detector distances of 75, 37.5 and 0 feet, respectively. This table gives the contribution from each of the 25-foot wide strips shown in Fig. 3 according to both calculational techniques

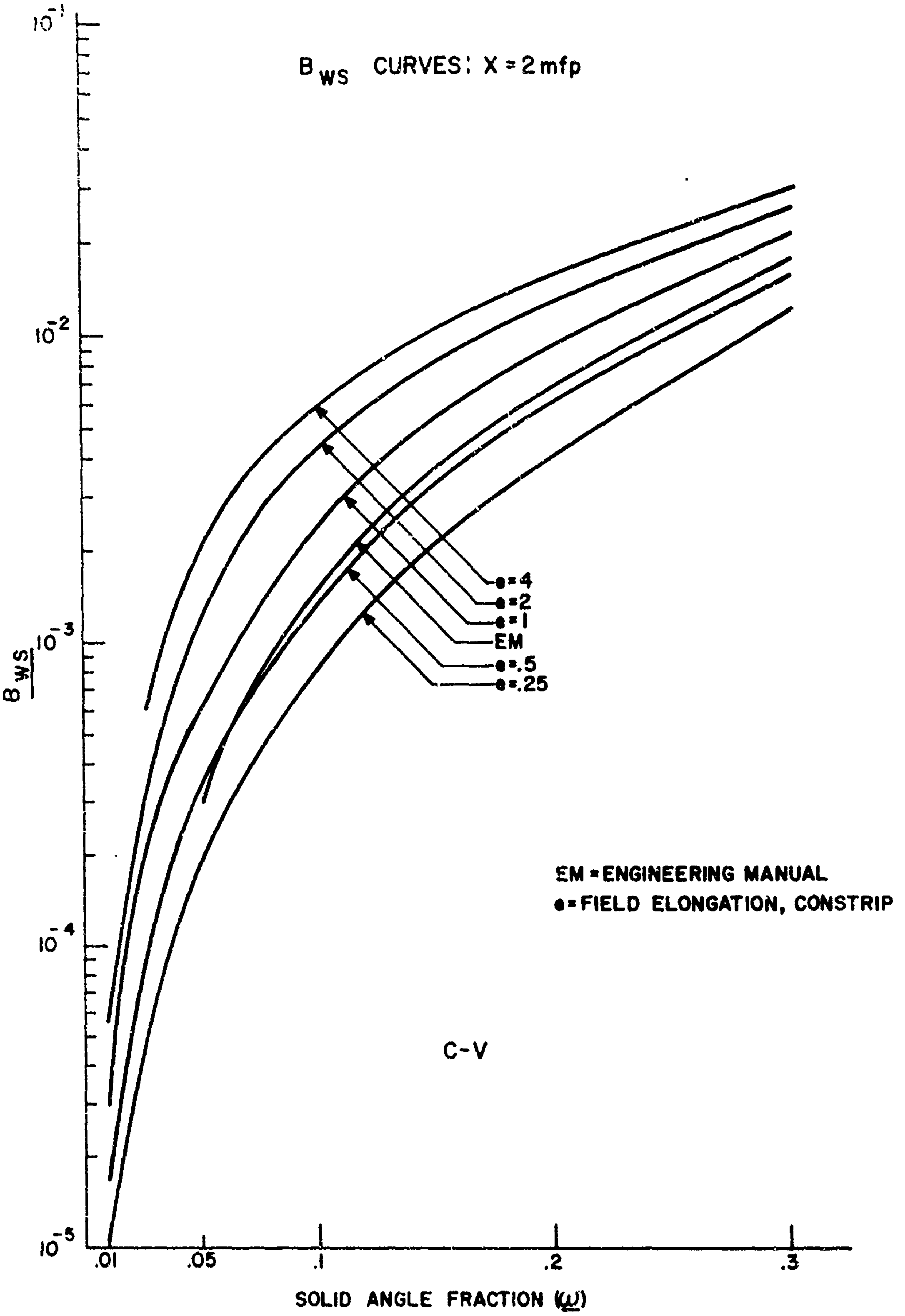


Fig. 8. B_{ws} as a Function of Solid Angle Fraction for Various Field Elongation.

Table VI

GROUND CONTRIBUTIONS FROM 25-FOOT STRIPS* ACCORDING TO CONSTRIP AND THE ENGINEERING MANUAL

Wall Weight (psf)	Strip No.	WALL DETECTOR POSITION (ZD = 0) CONSTRIP	E. M.	% DIFF	HALF-DETECTOR POSITION (ZD = 37.5 ft.) CONSTRIP	E. M.	% DIFF	CENTER DETECTOR POSITION (ZD = 75 ft.) CONSTRIP	E. M.	% DIFF
18	1	.14746	.15289	+ 3.7	.02139	.03380	+ 58.0	.00952	.01466	+ 54.0
	2	.03936	.04617	+ 17.3	.01193	.01238	+ 3.4	.00614	.00747	+ 21.7
	3	.02008	.01519	- 24.4	.00750	.00602	- 19.7	.00421	.00362	- 14.0
	4	.01233	.01307	+ 6.0	.00508	.00602	+ 18.5	.00303	.00299	- 2.3
	5	.00822	.01259	+ 53.2	.00362	.00505	+ 39.8	.00227	.00342	+ 50.7
	6	.00581	.01046	+ 80.0	.00267	.00505	+ 89.1	.00174	.00279	+ 60.3
	7	.00427	.00713	+ 70.0	.00203	.00287	+ 41.4	.00137	.00193	+ 40.9
	8	.00326	.00546	+ 67.5	.00158	.00218	+ 38.0	.00109	.00150	+ 37.6
		.24080	.26296	+ 9.2	.05581	.07338	+ 31.5	.02936	.03838	+ 30.7
36	1	.08889	.07800	- 12.3	.01362	.01844	+ 35.4	.00633	.00852	+ 34.6
	2	.02747	.02700	- 1.7	.00790	.00800	+ 1.3	.00414	.00489	+ 18.1
	3	.01460	.01900	+ 30.1	.00503	.00768	+ 52.7	.00283	.00478	+ 68.9
	4	.00922	.01050	+ 13.9	.00344	.00461	+ 34.0	.00204	.00254	+ 24.5
	5	.00627	.01200	+ 91.4	.00245	.00486	+ 97.6	.00152	.00318	+109.2
	6	.00449	.01100	+145.0	.00183	.00487	+166.1	.00117	.00289	+147.0
	7	.00334	.00850	+154.5	.00139	.00345	+148.2	.00092	.00225	+144.6
	8	.00257	.00600	+133.5	.00109	.00243	+122.9	.00073	.00159	+117.8
		.15684	.17200	+ 9.7	.03675	.05434	+ 47.9	.01968	.03064	+ 55.7
72	1	.03377	.02682	- 21.6	.00544	.00693	+ 27.4	.00266	.00344	+ 29.3
	2	.01262	.01383	+ 9.6	.00339	.00475	+ 40.1	.00183	.00296	+ 61.7
	3	.00697	.00954	+ 36.9	.00221	.00387	+ 75.1	.00125	.00243	+ 94.4
	4	.00456	.00256	- 43.9	.00154	.00115	- 25.3	.00091	.00061	- 33.0
	5	.00319	.00394	+ 23.5	.00112	.00159	+ 42.0	.00068	.00104	+ 52.9
	6	.00233	.00363	+ 55.8	.00084	.00160	+ 90.5	.00052	.00096	+ 84.6
	7	.00175	.00364	+108.0	.00064	.00148	+131.3	.00041	.00095	+131.7
	8	.00136	.00364	+167.6	.00050	.00148	+196.0	.00033	.00095	+187.9
		.06654	.06760	+ 1.6	.01568	.02285	+ 45.7	.00858	.01334	+ 55.5

* See Figure 3.

for each of the three detector locations. In most cases, the Engineering Manual values were higher. Percent differences ranged from 1.7 to 196 percent. There seems to be no definite pattern of percent differences; however, the closest agreements for the total field cases are obtained when the detector is adjacent to the wall.

In practically all cases, the Engineering Manual contribution from Strip 5 is greater than that from Strip 4. This unexplained rise may be due to the difficulty in reading B_{ws} values for large values of ω_s.

To calculate finite field contributions by Engineering Manual techniques, the length of the field is taken to be $L + 2W_c$ (length the wall plus twice the width of the field). Since this sort of geometry always gives a value of source field elongation (e_f) of less than 1 (Fig. 6), it is not surprising that the Engineering Manual calculated values in this study were generally higher than the CONSTRIP calculated values. (It was shown in RM-333-4[18] that CONSTRIP contributions were always lower than Engineering Manual contributions for low values of e_f -- cf Fig. 7.)

6. Comparisons with Experimental Data

Research Memorandum RM-333-3, Dose Rate from a Quarter-Circular Field,[19] contains the details of a study which was performed primarily for the verification of the CONSTRIP Program. Previous editions of the program had been limited to rectangular source fields, and the dose rate from a circular field had been calculated by the use of a "quarter-circle approximation," in which the area of the field is approximated by using a number of square patches. However, with the development of CONSTRIP V came the capability of calculating dose rates from irregular source fields to any specified degree of accuracy. This study was a comparison of the results calculated by the program to those obtained experimentally at the Protective Structures Development Center (PSDC).[20]

The experiment involved a quarter-circular source field of 452-foot radius which was subdivided into five areas (see Fig. 9). Detector heights varied from 1 to 33 feet. The theoretical (CONSTRIP) and experimental (PSDC) results are compared in Figs. 10-A through 10-E for each of the experimental areas. Figure 10-F gives a comparison of measured versus calculated dose rates for the entire quadrant.

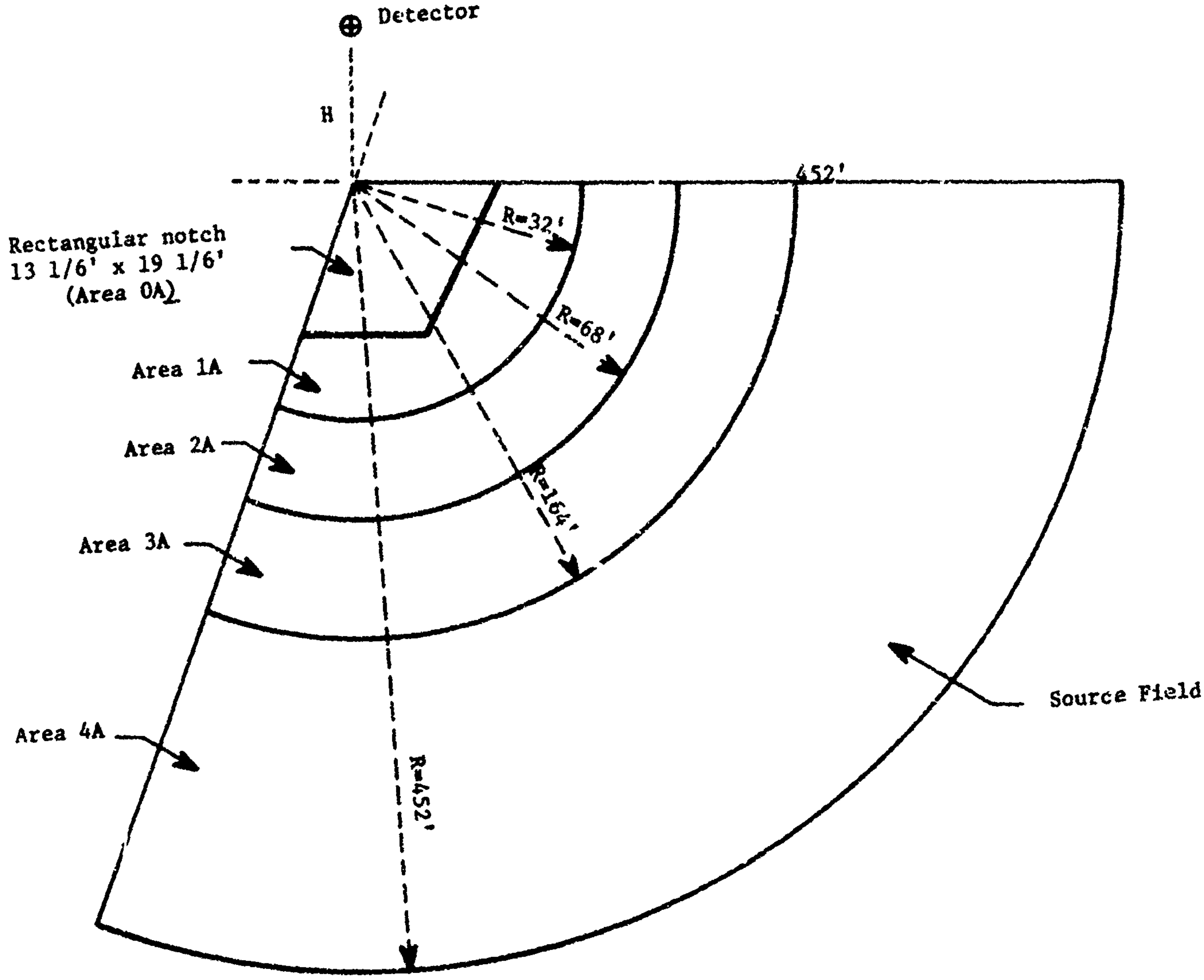


Fig. 9. Experimental Source Field Arrangement.

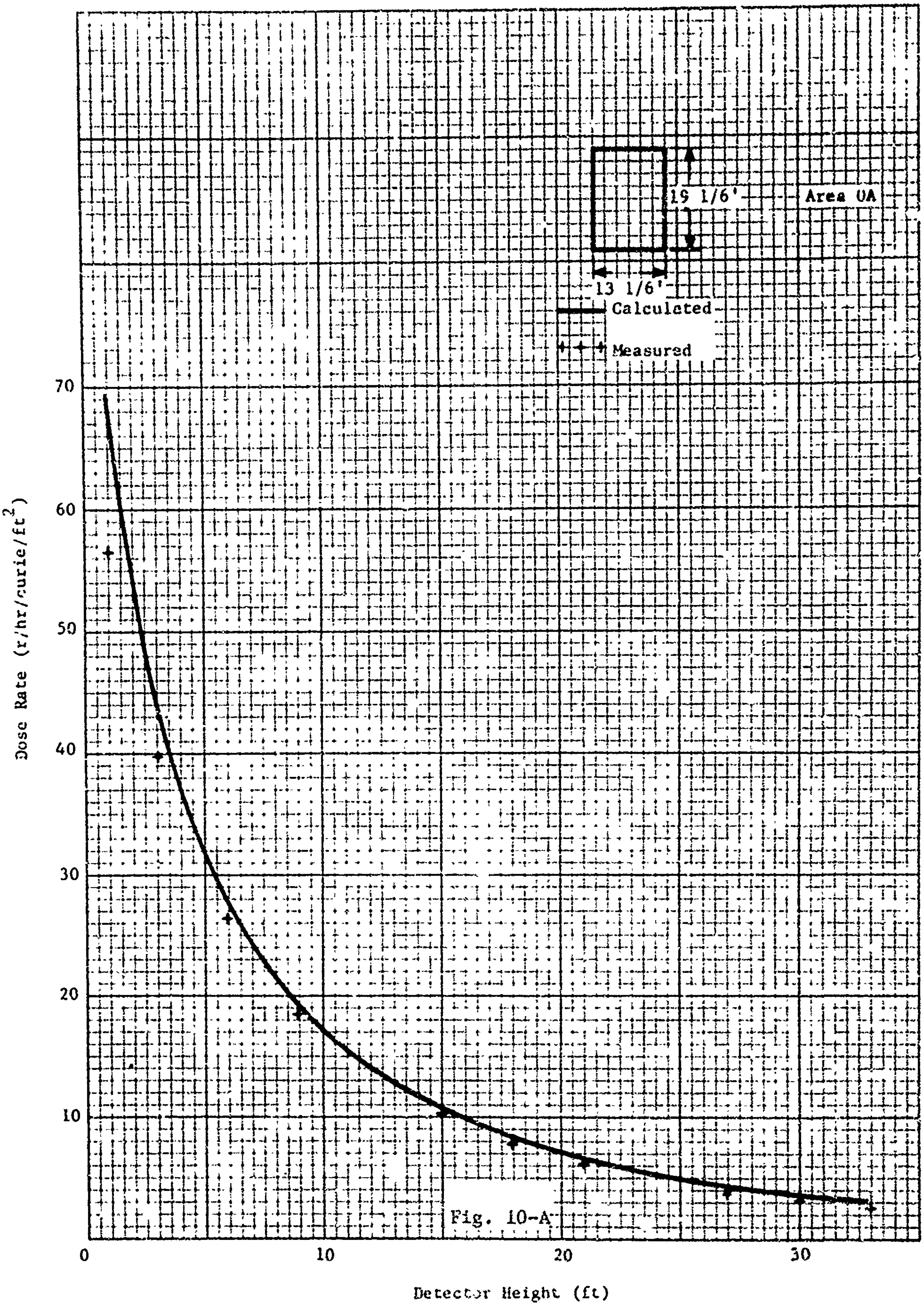
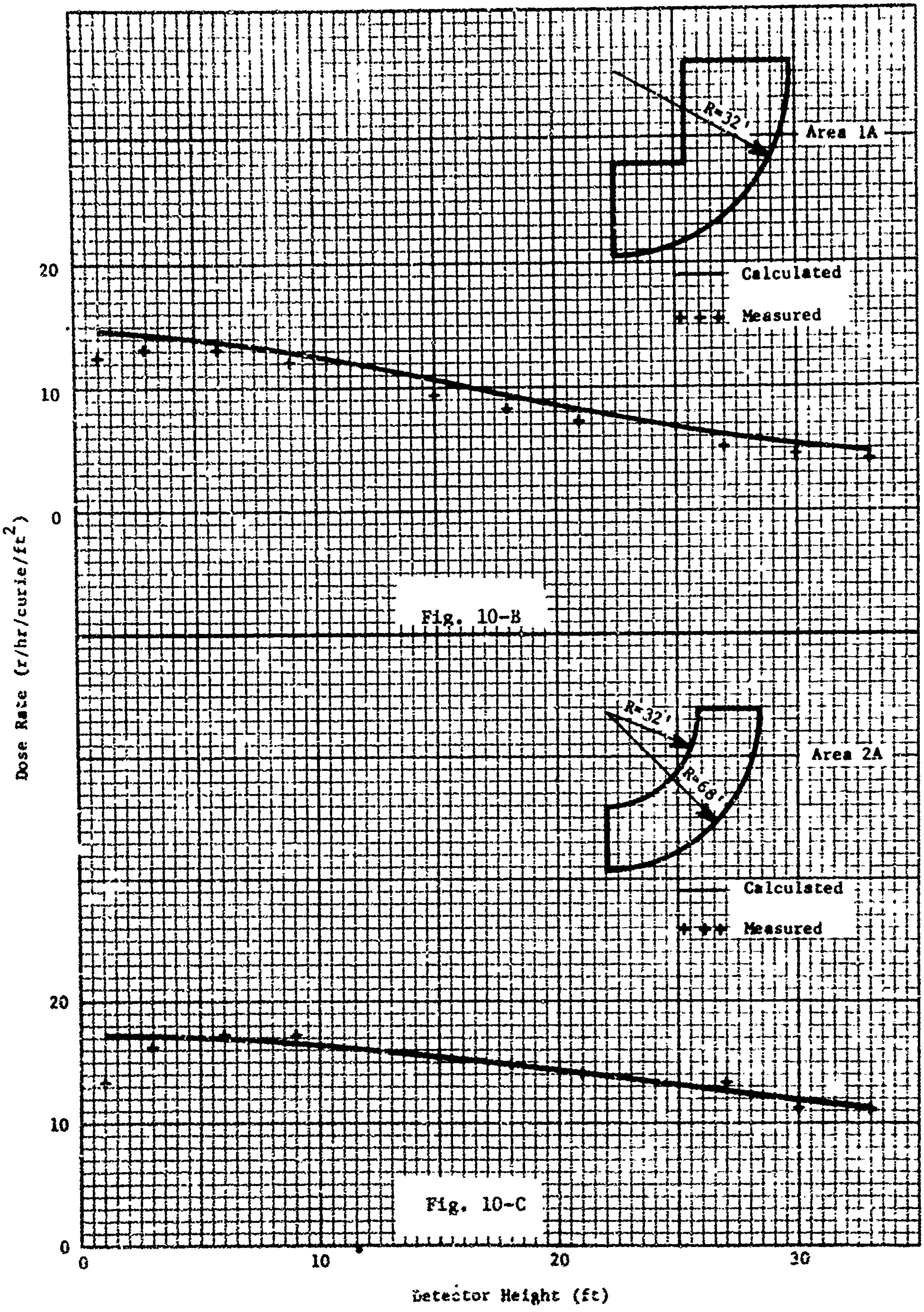


Fig. 10. Theoretical (CONSTRIP)/Experimental (PSDC) Comparison.


R=32'
Area 1A
Calculated
Measured
20
10
0
Fig. 10-B
R=32'
R=68'
Area 2A
Calculated
Measured
20
10
0
Fig. 10-C
0
10
20
30
Dose Rate (r/hr/curie/ft^2)
Detector Height (ft)

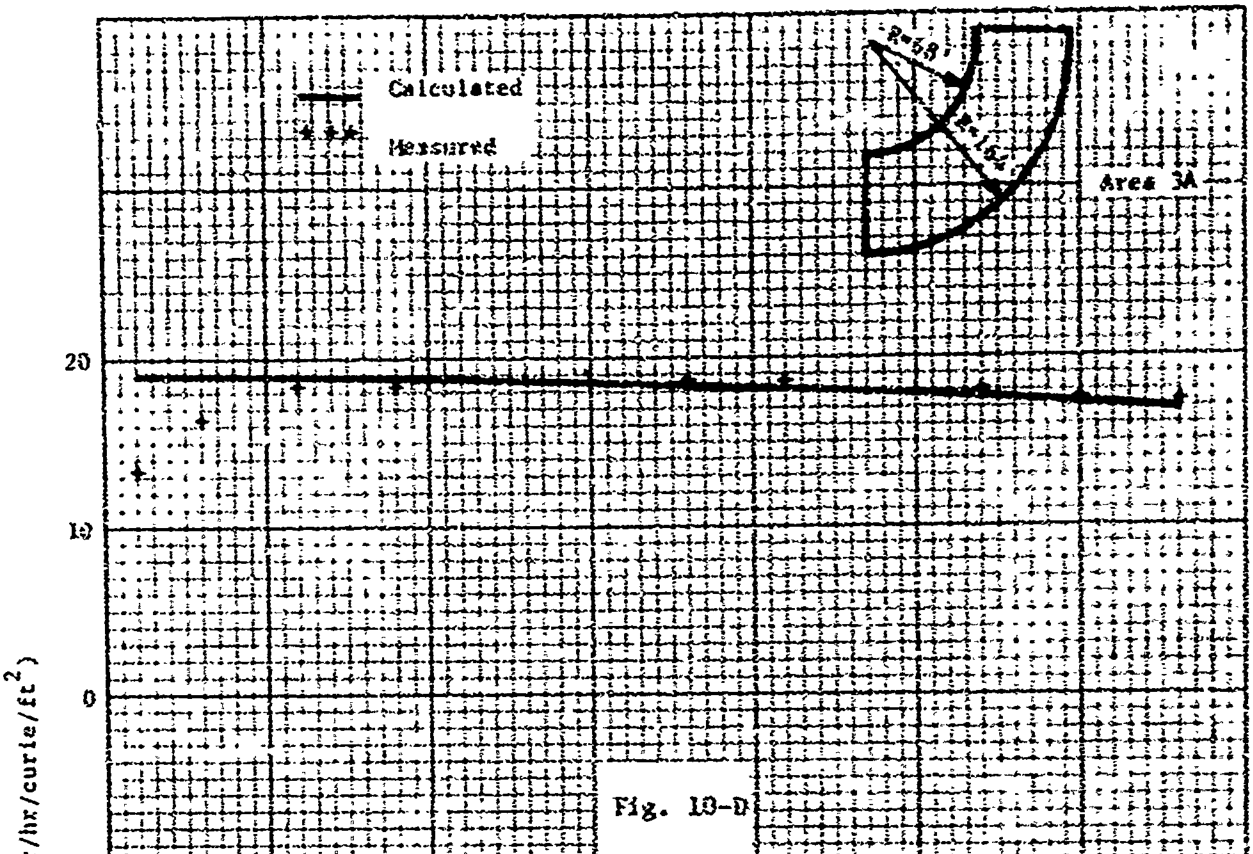


Fig. 10-D

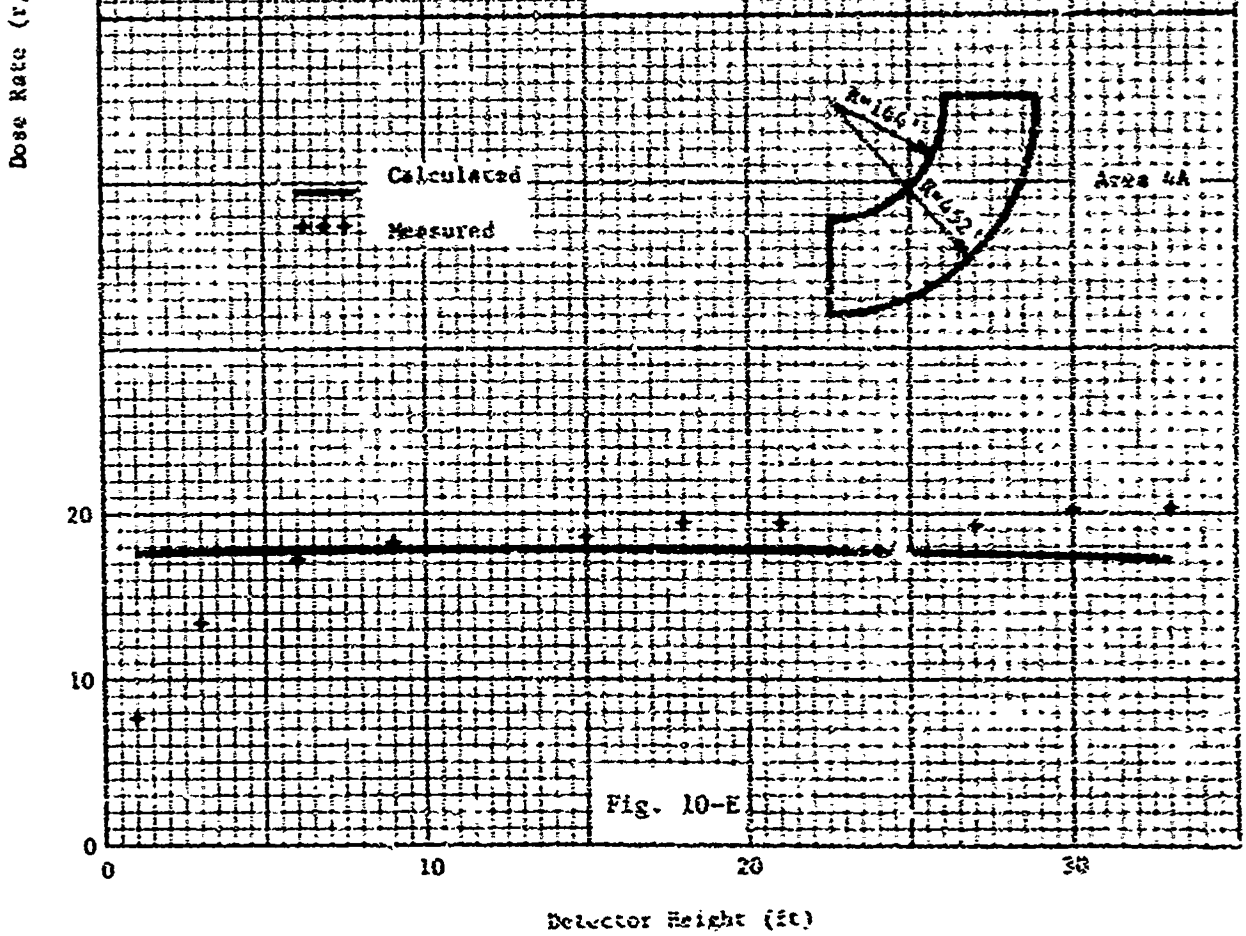
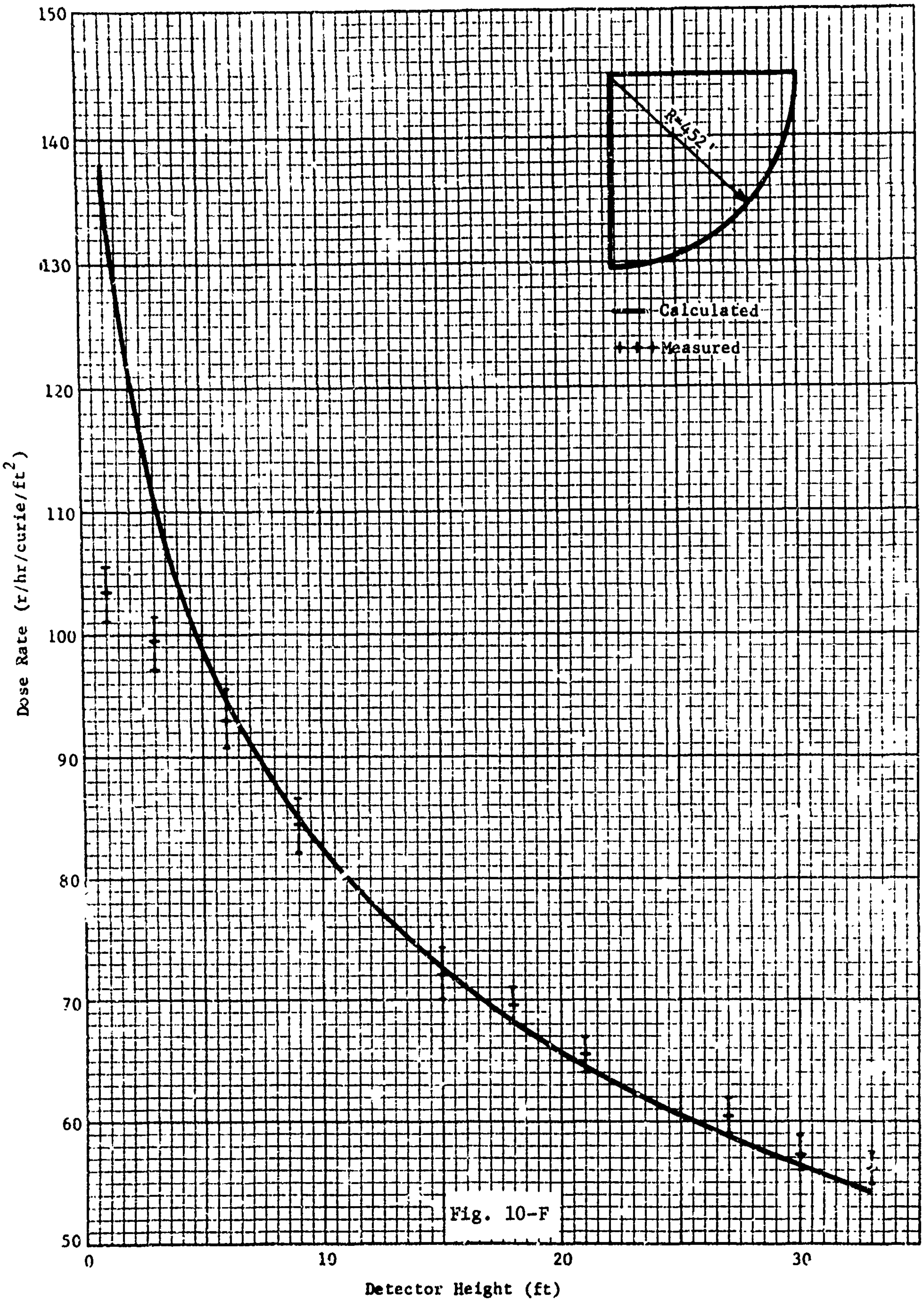


Fig. 10-E



150
140
130
120
110
100
90
80
70
60
50
Dose Rate (r/hr/curie/ft^2)
0
10
20
30
Detector Height (ft)
R=452'
Calculated
Measured

Fig. 10-F

Results obtained by CONSTRIP for complete field calculations agreed quite well with experimental values for detector heights of 6 to 33 feet. Calculated results were higher at the one- and three-foot heights, largely because of ground interface effects.

Overall conclusions reached from this study were: (1) that the CONSTRIP Program has the capability of calculating dose rates to a detector with a high degree of accuracy; and (2) that the results obtained justify the use of the present buildup factor (at moderate detector heights) for future studies.

Another comparison made with experimental data obtained at PSDC involved a 24'x36'x36' high three-story building partially surrounded by a uniform 50-foot wide strip of cobalt-60 contamination (simulated by the pumping of a small source through plastic tubing). A plan view of the configuration is shown in Fig. 11. The building, which is described in PSDC-TR-14,[20/] can be arranged to have walls of 4, 8, or 12 inches of concrete supported by steel I-beams spaced approximately 4 feet apart along the periphery of the building. A detailed description of the CONSTRIP input data, as well as a discussion of results, is contained in the CONSTRIP Program[2/] verification section of Part I of this final report. In general, CONSTRIP calculations agreed well with the experimental results, and the program can be used to accurately predict radiation penetration of actual structures to detector locations, 6 to 33 feet above ground level, and with somewhat lower accuracy outside this range. It should be noted, however, that this accuracy limitation is determined only by the reliability of the build-up factor input to the program, and may be expected to change as the accuracy and range of application of that build-up factor changes.

7. Recommendations for Decontamination Procedures

All of the studies performed under this project indicate that the greatest effectiveness in terms of increasing the countermeasure factor can be obtained by decontaminating first the roof of the structure if the detector location is within three stories of the roof, and, secondly, the space exterior to the structure's wall clearing uniform widths parallel to the walls of the structure. These conclusions are independent of roof and wall weight within the weights normally encountered in operational situations. Of course for exceptionally heavy roof and/or wall weights, these conclusions must be accordingly modified.

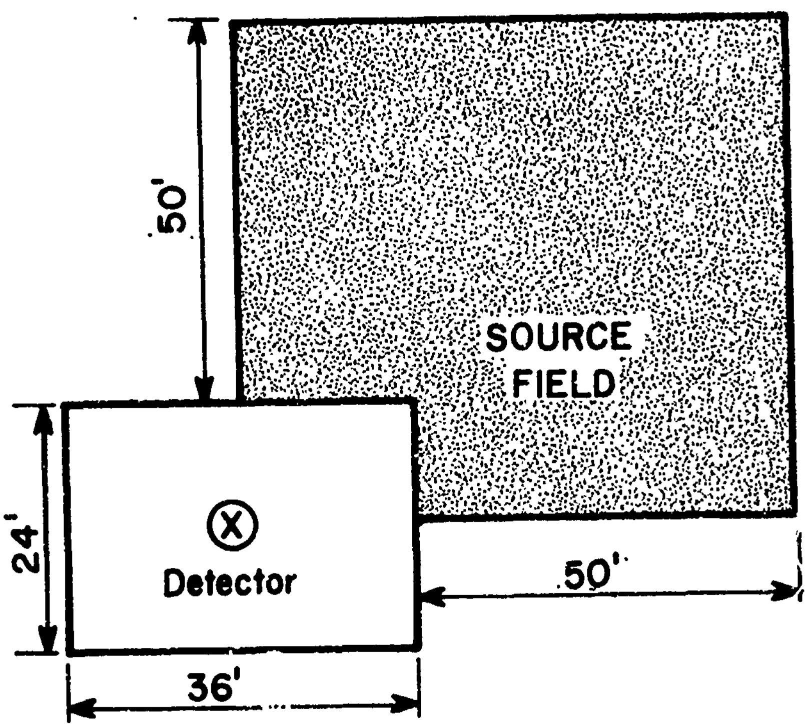


Fig. 11. Plan View of the PSDC Facility.

In case of limited planes of contamination (on the order of 200 feet width) removing fallout entirely for a distance of 50 feet surrounding a structure will yield a countermeasure factor of at least 2 at the center of the building providing the roof contribution has been first eliminated.

It should be noted that the maximum countermeasure factor which can be logically anticipated as a result of any limited decontamination effort is approximately 10. This is due to the contribution from sky shine in a structure which arises from sources fairly distant from the structure in question (sky shine is ordinarily of the order of 10 percent of the total contribution).

For a detector located adjacent a building wall, decontamination of the area outside that wall to a width of 25 feet will yield a countermeasure factor of approximately 2, providing the major contribution to the detector location is through the wall in question.

Using these rules of thumb as initial checks on decontamination procedures, it should be possible to ascertain whether in fact the correct decontamination procedure is being followed for any particular facility. By the time a particular side has been decontaminated to a distance of 25 feet, if a countermeasure factor of at least 2 has not been accomplished at a position adjacent the inside of the wall, the indications are that the major contribution is not being received through this wall. In such case alternate decontamination procedures must be considered, such as, the elimination of fallout exterior to other walls or from the roof of the building in question. Further definition of such activities must await future development; however, the potential for guideline development is shown by the above.

B. Field Application of Decontamination Analysis

1. Detroit Survey

As part of this overall effort as is called for in the Scope of Work, Appendix A, a brief survey of essential facilities was conducted in the Detroit area to determine building and source plane characteristics to be included in decontamination analyses. The facilities to be included in this survey were to be 21 in number and were to be identified in consultation with the contract technical monitor. From the results of this survey, common and special characteristics of buildings were to be identified for utilization in decontamination guideline development.

Analyses were to be performed utilizing CONSTRIP and other computer codes as required to determine effectiveness of decontamination of the facilities described according to common and special building and source plane characteristics. As a result of these activities, simple rules were to be drafted for later incorporation into guideline development for decontamination field operations.

The categories of buildings to be decontaminated within the post-attack recovery time period were separated into three orders of importance, and a tentative selection was made of facilities within each category to be covered in the survey. Since on-site permission for the survey was necessary, and since it was recognized that other conditions might render impractical the survey of a previously identified facility, the preliminary identification of survey facilities was tentative in nature. To the extent feasible, however, their selection was adhered to. The alternate choices that were made on-site were selected to reflect the characteristics of those originally identified. The facilities finally included in the Detroit Survey were 22 in number and are listed in Table VII.

Descriptions of the Detroit Survey facilities are given in Appendix B. While not all facilities are those given consideration prior to the survey, the facilities actually included are thought to reoresent those which would be of primary consideration in post nuclear attack decontamination operations. One use category that is not adequately represented in the survey is that of heavy industry as was initially intended by the selection of the Great Lakes Steel Corporation in Ecorse. However, facilities of this type have structural properties which are similar to those found in power plants and manufacturing facilities, such as are represented by the Fermi and Mistersky Power Stations, and by the Detroit Bolt and Nut Company. Therefore, the survey is thought to give a brief but reasonably comprehensive coverage to facilities of interest in this category.

2. Common and Special Characteristics of Buildings and Source Planes

Within the 22 buildings included in the Detroit Survey, a number of common source plane characteristics can be associated with buildings according to building type and use. As can be seen from a perusal of the

Table VII

FACILITIES IN THE DETROIT SURVEY*

A. First Priority

1. Medical

a. St. John's Hospital

b. The U.S. Public Health Service Hospital at Wind Mill Point

c. Providence Hospital

2. Power and Communication

a. Mistersky Power Station, Detroit (instead of the Detroit Edison Plant at Lycaste)

b. Fermi Reactor Power Plant at Monroe, Michigan

c. WXYZ Radio and TV Station (instead of the WWJ Radio Station at 9 Mile and N. Scotia)

d. Michigan Bell Exchange, Van Dyke and Whipple

e. Michigan Bell Exchange, 17151 Lahser Road

3. Water and Sewage Treatment

a. Waste-Water Treatment Plant at Ann Arbor, Michigan

b. City of Detroit Water Works

4. Fire and Police Facilities

a. State Police Headquarters at Grand River and 7 Mile Road

b. The Roseville Fire Department Headquarters

c. The Roseville Police Headquarters (instead of a second fire station)

5. Emergency Medical and Housing

a. Lingeman School in Detroit

b. Hale School in Riverview

B. Second Priority

1. Government Buildings

a. Municipal Building in Roseville, Michigan

b. Roseville DPW and Water Building in Roseville, Michigan (an additional facility - not included by type in the original selection)

2. Food Distribution

a. Kroger Food Store, Northland Shopping Center

3. Transportation Facilities

a. Detroit Metropolitan Wayne County Airport

C. Third Priority

1. Detroit Bolt and Nut Company (instead of the Great Lakes Steel Corporation in Ecorse)

2. Detroit Artillery Armory

3. Detroit Bank and Trust Company, Northland Shopping Center

* Parenthetical notes indicate on-site changes in the choice of surveyed facilities.

building and source descriptions included in Appendix B, the majority of the buildings have wide open areas surrounding them, almost independent of use and construction type. What buildings are in the surrounding areas are of light construction and afford little or no mutual shielding to the facility under consideration. Also, most of the areas surrounding the buildings are horizontal planes.

The most common exceptions to this occur when a single facility consists of two or more buildings. In these cases, different buildings of the same facility often form mutual shields. Such cases occur in each of the medical facilities, and in the sewage and water treatment facilities studied in the survey. Wayne Major Airport, which was selected as a transportation facility, also has different structures which serve as mutual shields, but the effects of these shields are diminished by their relative orientations. The Northland Shopping Center, which included two of the facilities studied, also had extensive mutual shielding; however, in this case, the two facilities were actually sub-components of a large complex and the rule of multiple structures in the same facility applies. In general, one can say that when a particular facility consists of a single structure, the surrounding area generally consists of either light structures which are not effective as shields, or of open planes susceptible to ready decontamination practices. For facilities of many structures, mutual shielding often is present.

Regarding the common structural characteristics of the facilities, it was noted that medical facilities are principally composed of buildings four or more stories high and consist of two or more independent buildings within the same facility. With few exceptions, other facility types have principal components which are three or less stories high though the structures may be quite tall (story height >> 10 feet).

Public service buildings and commercial buildings are usually surrounded by large open areas, either grassed or paved for parking. Other facilities serving the public indirectly, such as telephone exchanges and power plants, are located on streets of considerable width, or have nearby buildings of light construction.

The special characteristics that were encountered in the facilities studied generally consisted of provision for entrance into the structure, such as loading docks, garage doors, ramps, or partially covered entrance

ways. A review of the individual facility descriptions (Appendix B) shows that these special properties are generally encountered where industrial or commercial goods have to be moved in volume, or where special personnel handling conditions are present (such as emergency entrances in hospitals). Also, shopping complexes, such as the Northland Shopping Center, often have partially covered walk and entrance ways connecting stores and areas of the compound. Decontamination of these units will take special consideration since ordinary sweeping or firehosing of the roof may greatly increase the contaminant deposition under the entrance covering. Other special characteristics are notable in the wall weights of the buildings. Municipal and government structures have walls of medium to heavy weight, whereas commercial and industrial facilities often have walls of very light weight. Medical facilities are generally constructed with medium to heavy walls but have an abundance of window area which decreases the average wall weight considerably. Public service buildings such as communications and power generation facilities also have medium to heavy walls. An exception to this is noted in the case of the Fermi Power Plant which has corrugated asbestos walls over much of the structure.

3. Decontamination Analyses

The facilities described above and in Appendix B have been subjected to analyses for the contribution received at centrally located detector locations as a function of extent of contamination present. The analysis of these contaminated areas proceeded as follows: The buildings were subjected to evaluation using the PF-COMP Computer Program.[17/] This computer program utilizes Engineering Manual techniques[16/] to determine the protection factor at a number of detector locations within a structure as a function of contaminated planes exterior to the structure. The results o the PF-COMP analysis were utilized to ascertain the relative importance of contaminated fields on various sides of the structure. Following this, CONSTRIP was utilized to analyze the patterns of importance of the contamination in strips parallel to the walls of the facilities in the survey. The analysis method is based upon evaluating contributions from strips of the external source parallel to the side of the structure under investigation. In these evaluations, which are described in detail

in Appendix C, Decontamination Analyses of Detroit Facilities, the relative contribution from each strip was determined for each of the important walls as indicated by the PF-COMP calculations. Analyses of the facilities included in the Detroit Survey indicated two things.

First of all, the most important general consideration for decontamination is fallout on the roof of the structure involved. The buildings included in the survey are predominantly of few stories in height and of large floor area. For this type of structure the predominant contribution to a detector location in the center of the building is that which comes from the roof source.

The second characteristic noted in analysis of the survey results is that decontamination of exterior planes is very useful in the case of limited strips of fallout contamination; however, the case is not so clear for infinite planes of fallout contamination. In fact, no general rule has yet been ascertained for effectiveness of limited strip decontamination in the case of large fallout fields. This will be a prime area for future investigations if guidelines are to be determined for decontamination of structures with large open areas surrounding them.

However, for facilities with limited source fields (fields which are 200 feet or less in width, measured perpendicular to the walls of the structure), decontamination of a strip along the building wall which is the length of the wall and 40 percent of the distance to the width of the contaminated field (perpendicular to the wall) will yield a countermeasure factor of at least two in most cases. Decontamination of the adjacent 20 percent of the width of a limited field of contamination will produce a countermeasure factor at the center of most structures of 1.4. Details of these considerations are given in Appendix C.

C. Rules for Decontamination Operations

Based upon the conclusions of the analyses described above, the only general rules which are evident are: (a) clean off the roof of the structure in question, unless the area to be occupied is three or more stories below the roof, or unless the roof is of extremely heavy construction; (b) decontaminate limited planes of fallout to take maximum advantage of other obstructions to fallout radiation; and, last of all, (c) attempt to clean up infinite planes of contamination to achieve the required countermeasure factor.

In the case of structures with predominantly infinite fields of contamination, a possible alternative to large area decontamination may be worth considertaion. Such an alternative might be the erection of earthen barricades at some distance from the facility with decontamination of the intervening area. Such barricades would be placed at a sufficient distance and would be of sufficient height to shield the detector location from virtually all of the wall adjacent corridor* beyond the barricade.

III. RECOMMENDATIONS FOR FUTURE RESEARCH

It is obvious from the conclusions of the analytical studies and the Detroit Survey conducted in this effort that the greatest benefit in decontamination operations is obtained by removing fallout deposition from limited areas, or planes of contamination. However, further research is necessary to determine the extent of decontamination effort that should be placed upon the removal of fallout from large areas of deposition. As may be seen in Appendix C, the results of analyses of fields of this category are inconclusive. In order to separate the wide variation in effectiveness of such decontamination efforts, the results noted in Appendix C must be subjected to further analysis. It is suggested that further analyses be run to determine the common and special characteristics of structures and/or source fields that are predominantly responsible for the predicted dose rates in essential facilities bordered by large planes of contamination.

It is also recommended that further analyses of structures be performed to broaden the experience gained in the Detroit Survey. From these analyses a general description of operational procedure should be forthcoming which will be amenable to codification into guidelines for decontamination operational personnel.

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* The wall adjacent corridor is a portion of a field bounded by the shielding wall and lines perpendicular to and at either end of the wall (cf. Fig. 3, page 9, strips one through eight form a wall adjacent corridor).

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Appendix A

Scope of Work

Appendix A

Scope of Work

The Scope of Work of Contract Number N0022867C2297, OCD Work Unit 3233B, is directed toward meeting the objectives of the research study which are: (1) to increase the flexibility and utility of the CONSTRIP Program, and (2) apply this program to the determination of decontamination effectiveness of urban areas. Specifically, the contract work effort included work to:

1) Include in the CONSTRIP Program a capability of calculating barrier shielding for walls with lower edges other than the level of the source plane.
2) Incorporate a routine in the CONSTRIP Program which will interpolate Monte Carlo data for wall thicknesses other than those for which specific calculations have been run, enabling the program to calculate dose angular distributions received by a point detector for arbitrary wall thicknesses.
3) Develop the technique of calculating dose rates at a point detector from source shapes characteristic of urban areas. (This will incorporate effects of shielding buildings on radiation incident on a wall.)
4) Compare the results of the current engineering calculations of the protection afforded by wall barriers against ground fallout contamination with those obtained with the CONSTRIP Program.
5) Based on 4), make recommendations for decontamination field operations.
6) If required, calculate the protection afforded by damaged buildings as provided for in the five cities study.
7) Conduct a brief survey of essential facilities in the Detroit area to determine building and source plane characteristics to be included in decontamination analyses. The facilities to be included in the survey were limited to 21 in number, and were to be identified in consultation with the contract technical monitor.
8) From the results of the survey to find common and special characteristics of buildings to be utilized in decontamination guideline development.
9) Perform analyses using CONSTRIP or other computer codes as required to determine effectiveness of decontamination of facilities described according to common and special building and source plane characteristics.
10) Draft simple rules to be later incorporated into guidelines for decontamination field operations.

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Appendix B

Detroit Survey Facilities

Appendix B

Detroit Survey Facilities

The facilities studied in the Detroit Survey were those typifying structures of greatest possible interest in decontamination field operations. The facilities are not intended to be those primarily functioning as fallout shelters, but are intended as examples of structures for which occupancy is necessary in order to insure minimum acceptable operational status of the community in a postattack environment. These structures, which have been broken down in the categories described in the text of this report, are described herein in some detail as to the individual characteristics of the facilities studied. For purposes of broad classifications, wall weights are classed as:

1) Very light - 0 to 19.9 psf
2) Light - 20 to 39.9 psf
3) Medium - 40 to 79.9 psf
4) Medium Heavy - 80 to 119.9 psf
5) Heavy - 120 to 159.9 psf
6) Very heavy - 160 psf or more

Roof and floor weights are classed according to:

1) Light - 0 to 9.9 psf
2) Medium - 10 to 29.9 psf
3) Heavy - 30 to 49.9 psf
4) Very heavy - 50 psf or more

A brief description of the individual facilities follows; where possible plot plans are included to clarify the descriptions as are selected photographs of the principal structures.

1. St. John Hospital - Detroit, Michigan.

The St. John Hospital is composed of a main structure, and three peripheral structures. The main structure consists of an eight story building with maximum dimensions approximately 200x320 feet, plus a wing off one side, approximately 140x50 feet (the dimensions of the main structure are maximum right angle dimensions in any part of the structure -- as seen in Fig. B-1a), the building actually consists of a series of long wings extending to the front and rear off a principal section. The walls of the main structure are very heavy and contain windows and other apertures as shown in Figs. B-1b and B-1c.

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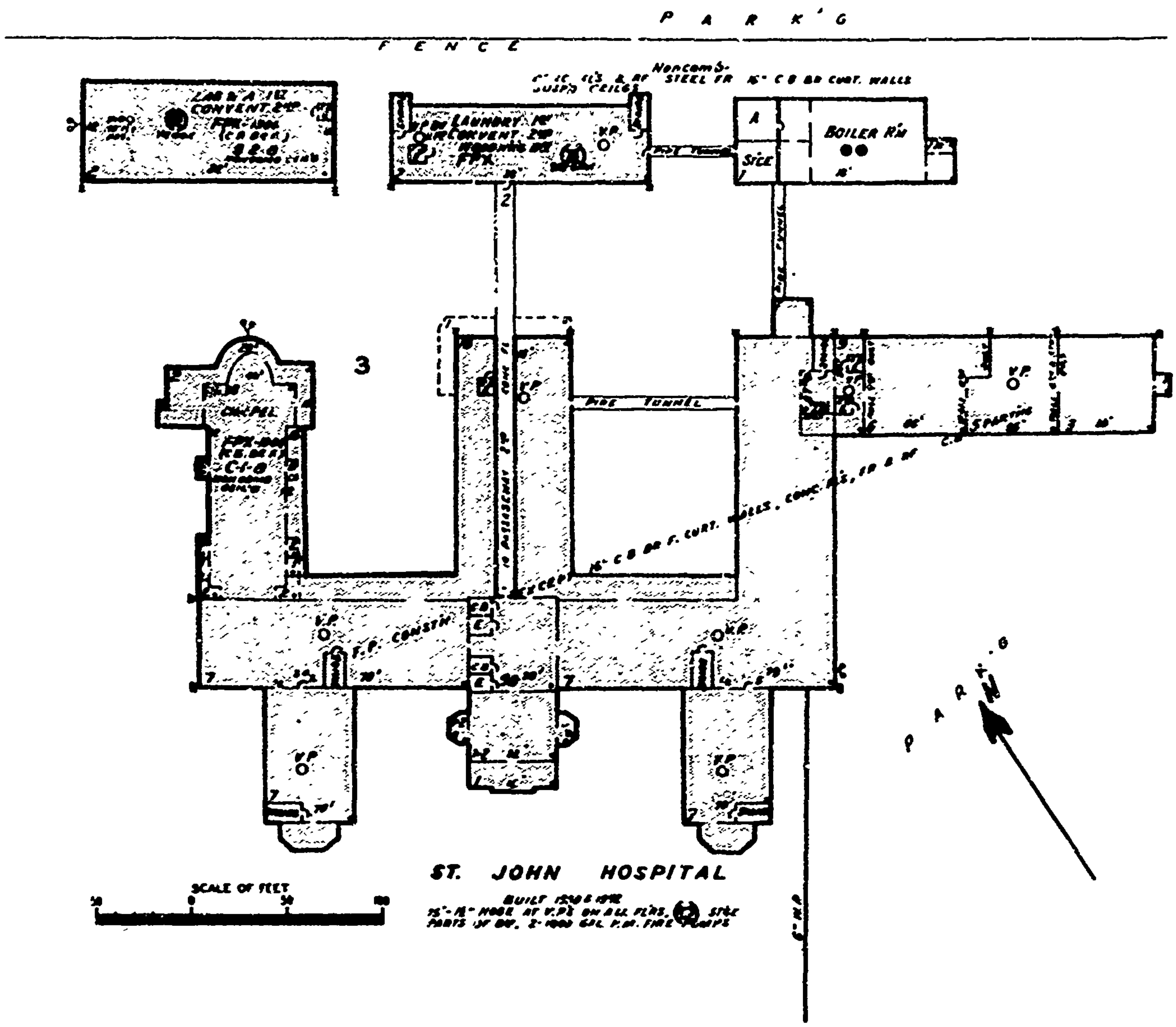

Fig. B-1a. St. John Hospital (Plot Plan)

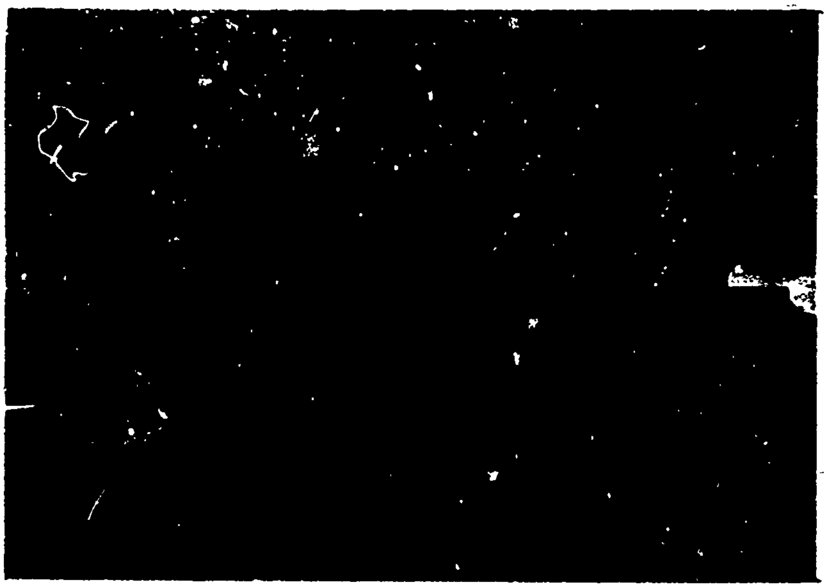

Fig. B-1b. St. John Hospital (Front View).

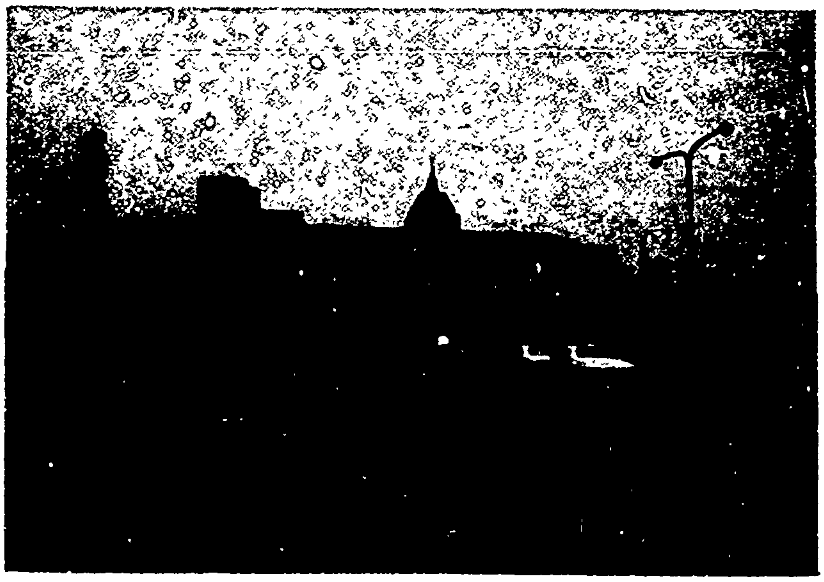

Fig. B-1c. St. John Hospital (Rear View).

The floors and roof of the structure are also very heavy. Some 60 feet in back of the main hospital building are three auxiliary buildings 120 and 230 feet in height. These buildings are shown in the rear view of the hospital (Fig. B-1c) and are of sufficiently heavy construction to act as mutual shields to the main hospital structure.

2. United States Public Health Service Hospital at Wind Mill Point, Detroit, Michigan.

The main structure of this facility is unique in shape. It consists of a central connecting section with five wings as shown in the plot plan of the facility (Fig. B-2a). In addition to the principal structure, there are three nearby service buildings and a garage, and farther away, residences for some of the hospital staff. With the exception of the front of the building (Fig. B-2b) and the northeast wing, the main structure is four stories in height. The exceptions are three stories in height. The garages shown in the plot plan are approximately 15 feet in height. The other surrounding structures are 30 to 45 feet high. All are of sufficiently heavy construction to act as mutual shields to the main hospital building. Other than the concrete ramp, shown left of center in Fig. B-2c, there are no special building characteristics encountered in the facility. The surrounding area is as shown in the plot plan and the windows and other apertures for the entire structure are typical of those shown in the photographs. The walls are of medium weight construction. The roof is medium weight and the floors are of heavy construction.

3. Providence Hospital

Providence Hospital is a rather complicated structure as shown by the front and side view photographs of the facility (Figs. B-3a and B-3b). The front and principal portion of the hospital is seven stories high, while the rear portion consists of three- and four-story sections. As shown in the side view, this facility has a loading dock which is used for bringing supplies into the facility. The emergency entrance, not shown in the photographs, is at ground level at the rear of the structure and is a covered dock similar to the one shown in the side view. Either of these docks could be used in a postattack situation as an emergency entrance. The structure has medium weight walls, light roof, and very heavy floors. The surrounding areas are typical of those shown in the photographs of the facility, consisting primarily

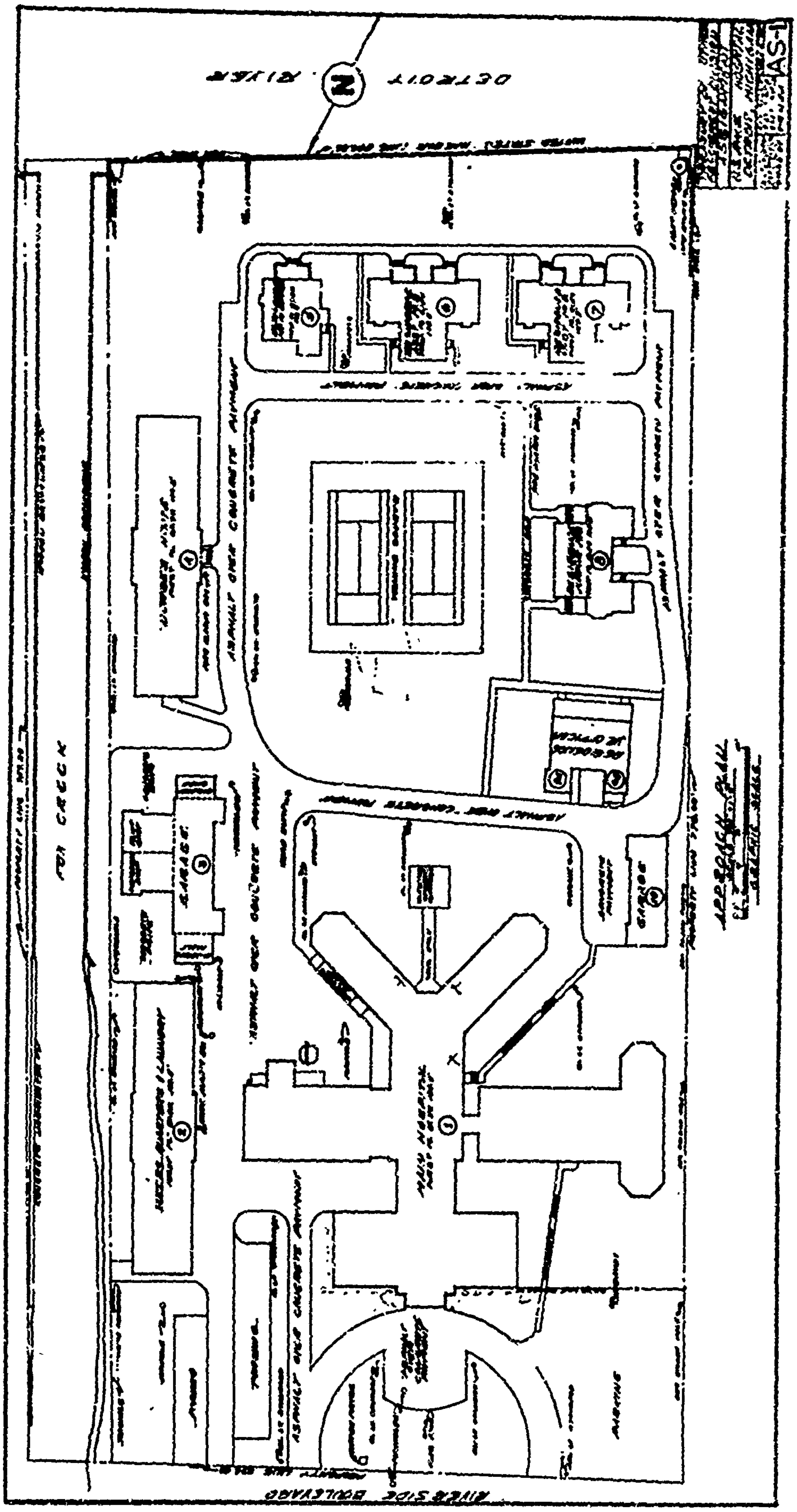

Fig. B-2a. U.S. Public Health Service Hospital (Plot Plan).

Fig. B-2b. U.S. Public Health Service Hospital (Front View).

Fig. B-2c. U.S. Public Health Service Hospital (Concrete Ramp).

Fig. B-3a. Providence Hospital (Front View).

Fig. B-3b. Providence Hospital (Side View).

of paved parking lots and some grassed lawns. Mutual shielding is afforded different parts of the building by other parts of the structure, and also to some small extent by one building located approximately 100 feet and a second building approximately 200 feet to the rear of the main structure.

4. The Mistersky Power Station

This facility consists of a large structure of very heavy walls and medium weight floors and roof, and several smaller peripheral buildings as shown in the plot plan of the facility (Fig. B-4a). The area surrounding the structures is flat gravel and cinder with the exception of the fuel storage pile behind the facility. The photographs, Figs. B-4b and B-4c, give views of the northeast side of the facility including the machine shop and office building which acts as a mutual shield to the main structure. Also shown is the southwest view of the rear of the structure (Fig. B-4d) showing the coal conveyor system and fuel storage area.

5. Fermi Reactor Power Plant at Monroe, Michigan

As shown in the aerial photograph of the facility (Fig. B-5), this power plant consists of a nest of individual structures. The part of the facility that would have to be operational in a postattack situation is the tall portion of the largest building shown in the photograph. This portion of the structure contains the control room and turbines for power production. The walls of the structure are extremely light being composed of Transite, a corrugated asbestos material approximately three-eights of an inch thick. The built-up roof is also of light weight. The other parts of the facility form mutual shields for this critical area; however, their construction, with the exception of the reactor shell and the shielding wall adjacent to the reactor shell, is also of very light weight. Characteristics of the area surrounding the facility may be seen from the photograph. This area consists mainly of flat gravel and water. The facility is located on a point which extends into the Detroit River, and practically all of the land area of the facility is shown in the photograph. Water lies to the front of the view shown, and to the left and right.

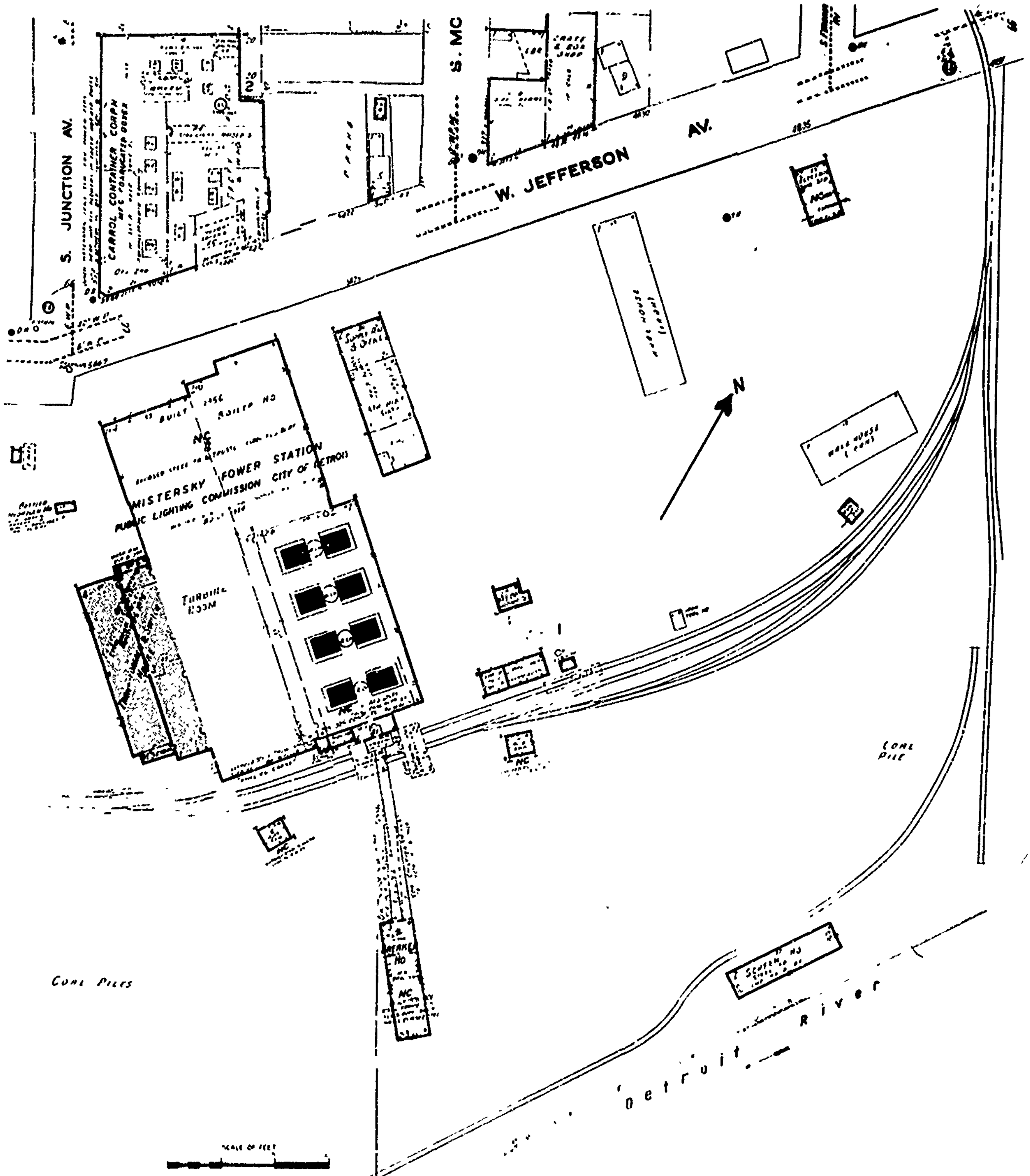

Fig. B-4a. Mistersky Power Station (Plot Plan).

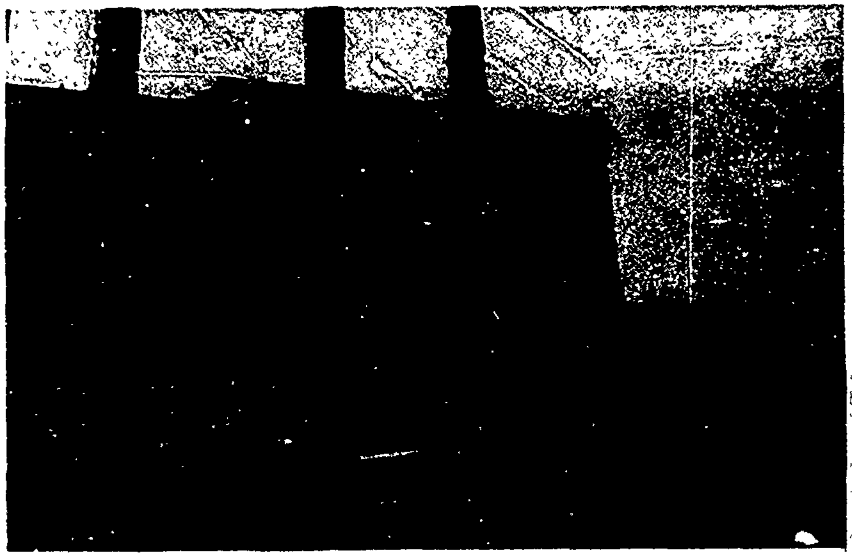

Fig. B-4b. The Mistersky Power Station (Northeast Side View-Front).

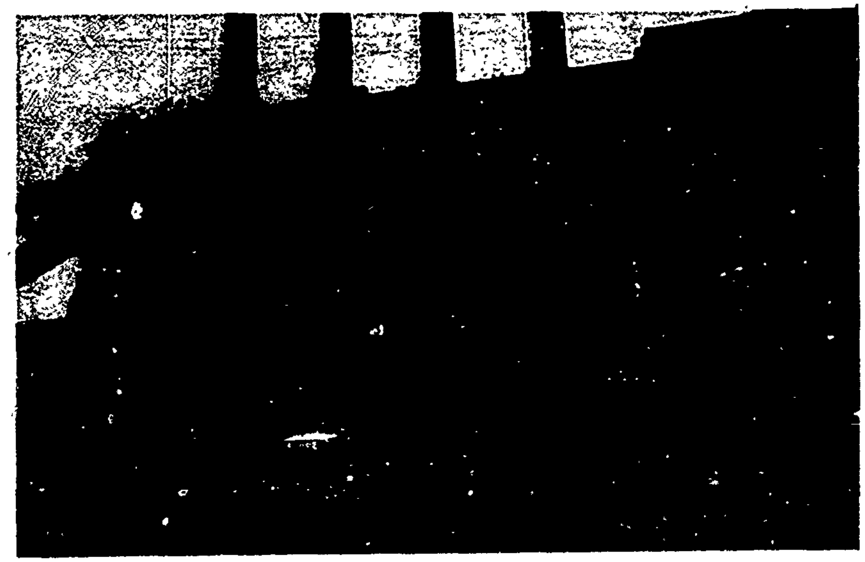

Fig. B-4c. The Mistersky Power Station (Northeast Side View-Rear).

Fig. B-4d. The Mistersky Power Station (Southwest View-Rear).

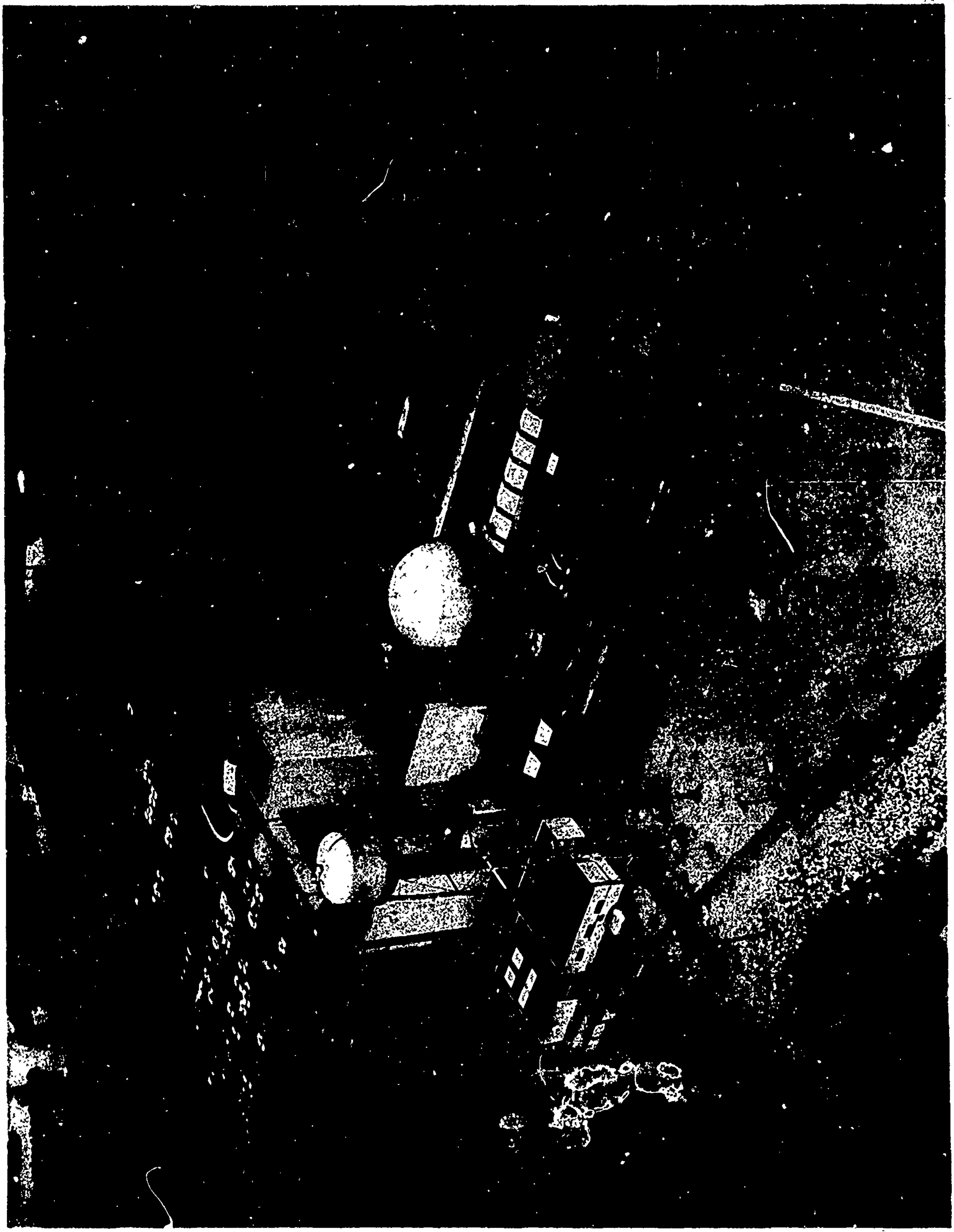

Fig. B-5. Fermi Reactor Power Plant (Aerial View).

6. WXYZ Radio and TV Station

This facility consists of a single structure, approximately 150x222 feet in dimension. The front portion of the structure, as shown in Fig. B-6a, is a one story building; the rear portion is two stories. The main operational center is in the rear portion, the front area being primarily office space and reception area. The structure has a medium weight roof, heavy floors, and medium heavy exterior walls.

The area surrounding this radio and TV station is composed primarily of a horizontal, grassy surface. At the right rear of the structure, as shown in the second photograph (Fig. B-6b), is a covered parking area and a parking lot which extends along the entire side of the two-story portion of the building and runs perpendicular to the building approximately 420 feet. Other than this parking area, there are no unusual construction characteristics about the facility.

7. Michigan Bell Telephone Company, Whittier Automatic Exchange (on Van Dyke)

This is a three story structure with very heavy walls, roof, and floors. It is surrounded on three sides by paved streets, and on the fourth by an alleyway, as shown in the illustrations (Figs. B-7a--B-7c). Opposite the facility on Ferry Avenue is a three-story school building which acts as a mutual shield to the facility. Other structures near the facility are of light construction and afford no appreciable shielding.

8. Michigan Bell Telephone, Redford Exchange (on Lahser)

This facility is a three-story building of medium heavy walls and heavy roof and floors. As shown in the illustrations (Figs. B-8a--B-8c), it is surrounded on three sides by paved streets and/or parking areas and on the fourth side by a lot containing small structures, which partially shield the facility. Other structures are situated on opposite sides of the streets. At the front of the facility, across Lahser Road, these structures are of light construction and are approximately 200 feet away, affording little mutual shielding. The structures opposite the facility on Argus Avenue are approximately 40 feet away, are approximately 20 feet in height, and are of sufficiently heavy construction to provide mutual shielding. At the rear of the structure, the horizontal paved surface extends across a parking lot and Roxdale Avenue and constitutes a

Fig. B-6a. WXYZ Radio and TV Station (Front View).

Fig. B-6b. WXYZ Radio and TV Station (Right Rear View).

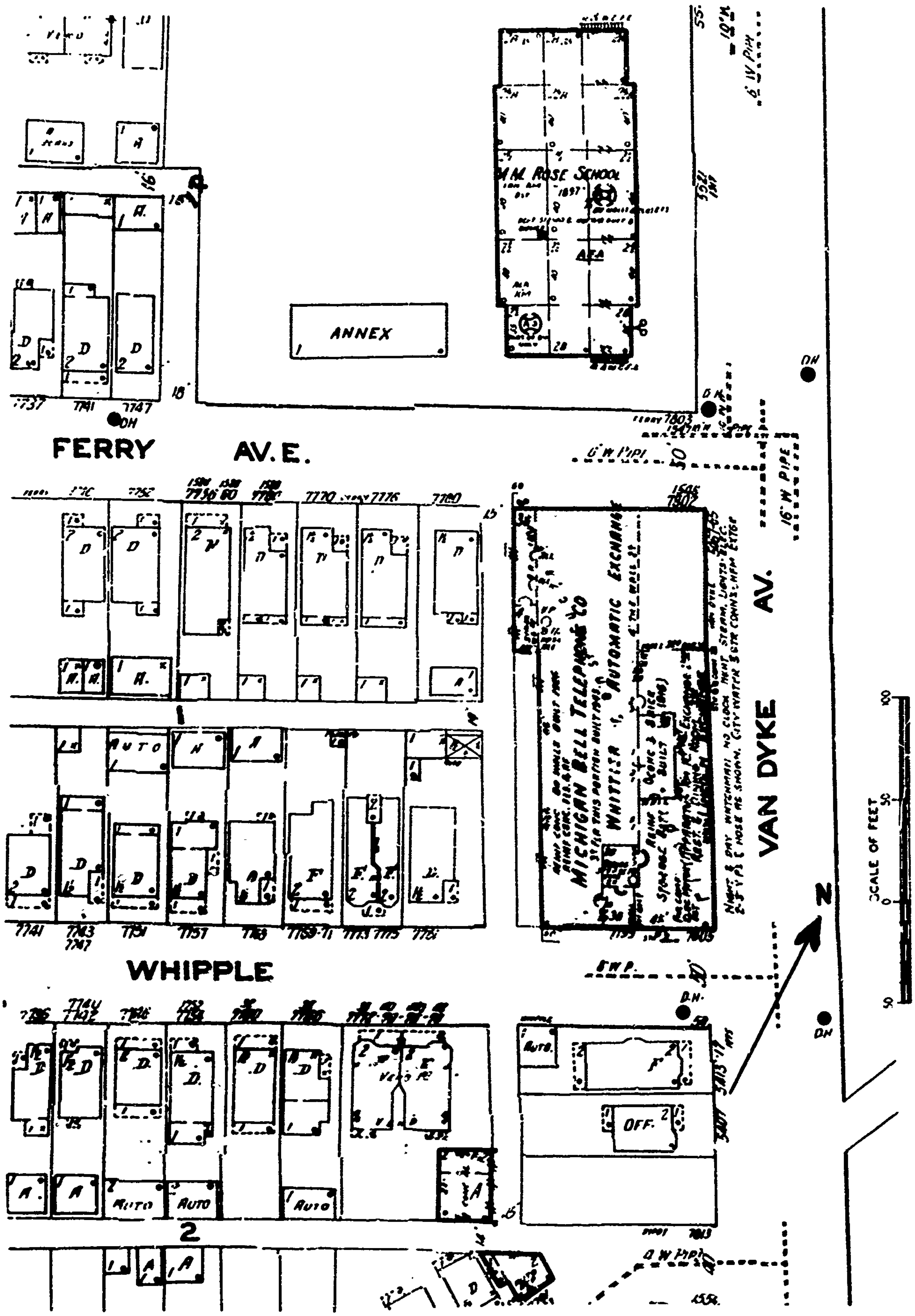

Fig. B-7a. Michigan Bell Telephone Company (Whittier Automatic Exchange).

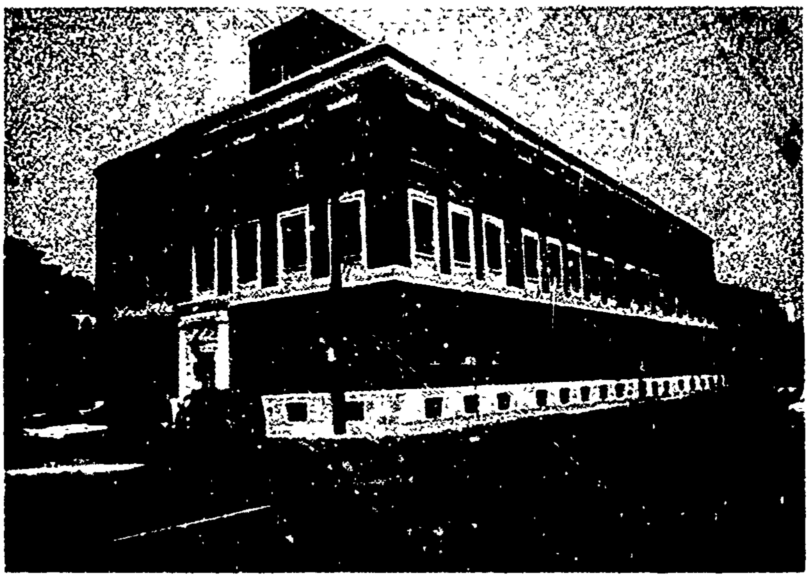

Fig. B-7b. Michigan Bell Telephone Company
(Whittier Automatic Exchange - Front View).

Fig. B-7c. Michigan Bell Telephone Company
(Whittier Automatic Exchange - Rear View).

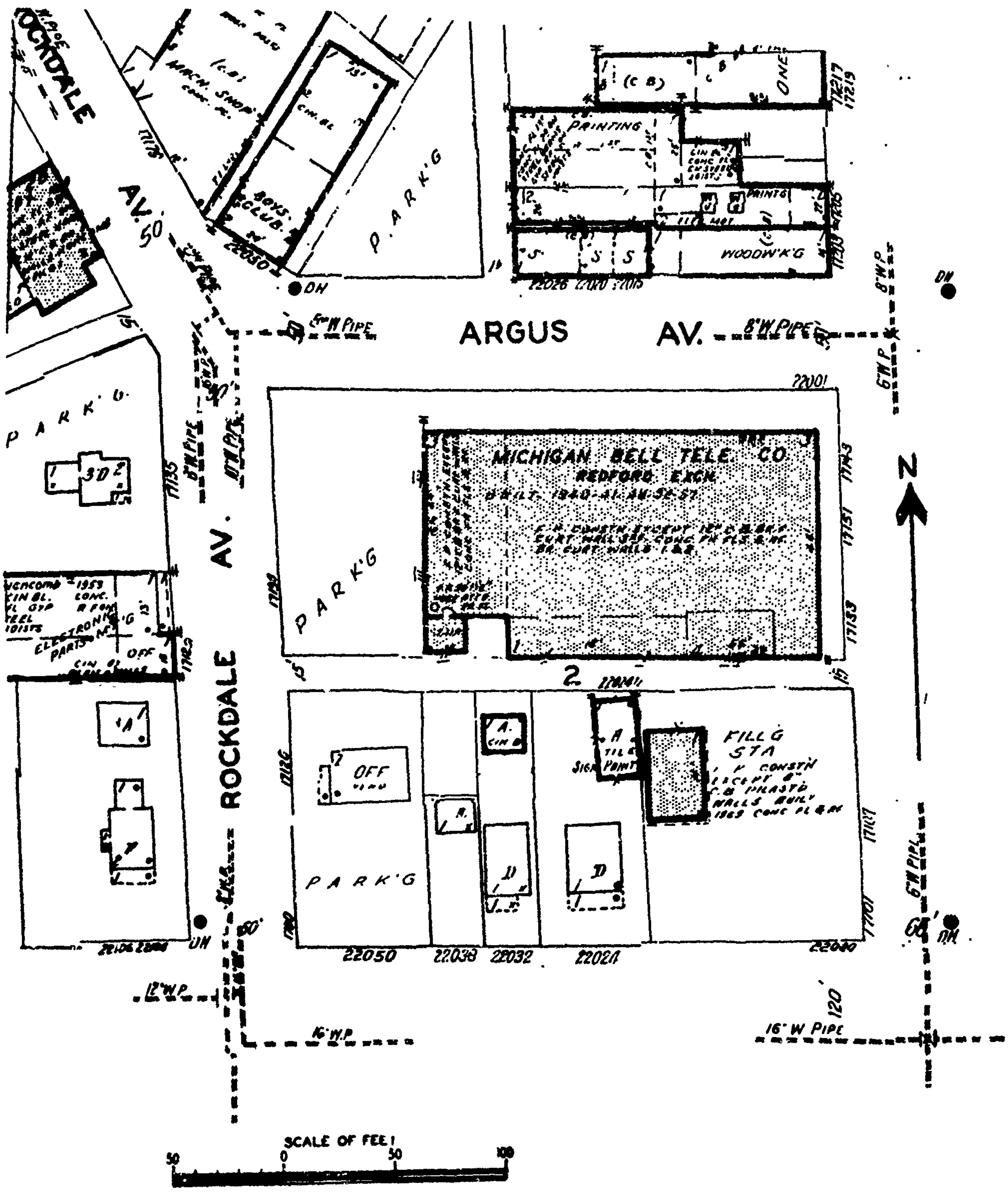

Fig. B-8a. Michigan Bell Telephone - Redford Exchange (Plot Plan).

Fig. B-8b. Michigan Bell Telephone - Redford Exchange.

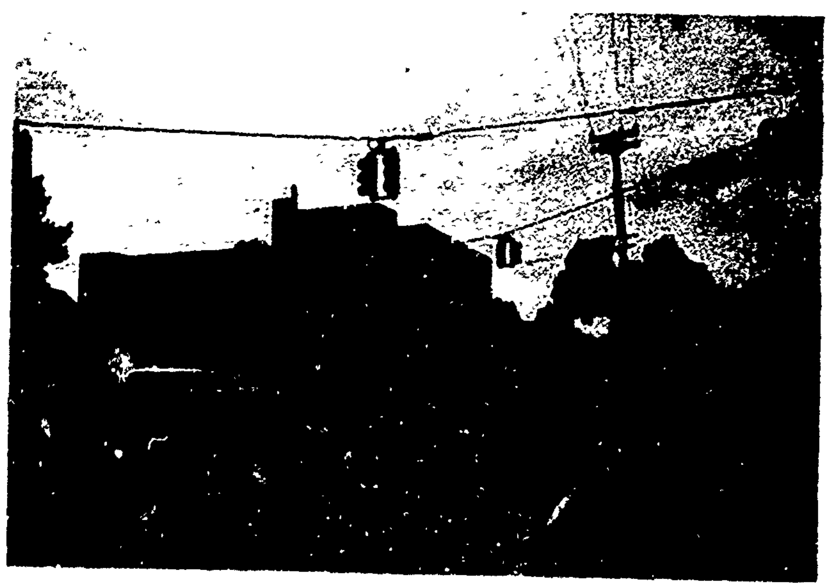

Fig. B-8c. Michigan Bell Telephone - Redford Exchange.

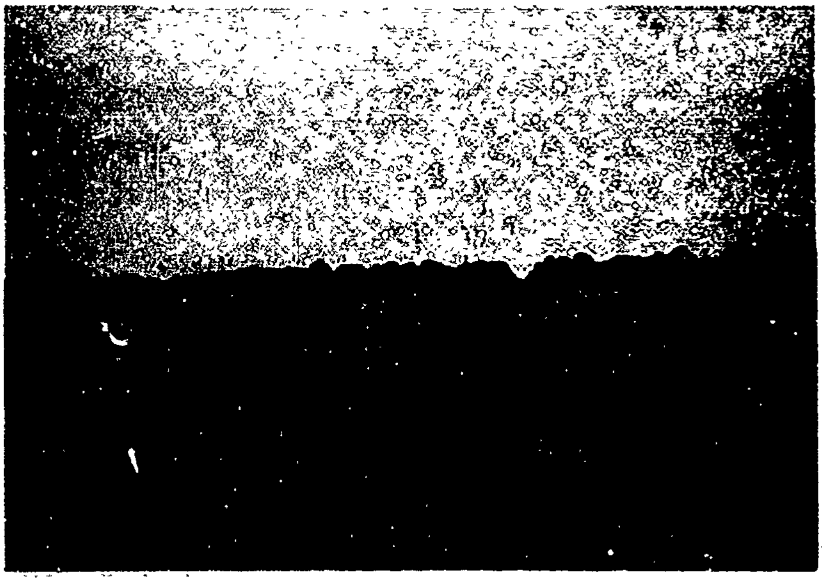

Fig. B-9a. Waste-Water Treatment Plant (North View).

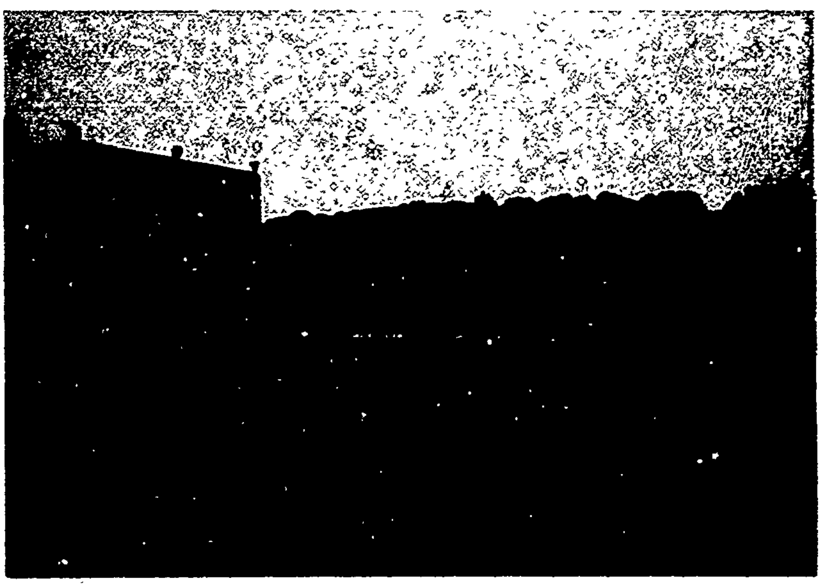

Fig. B-9b. Waste-Water Treatment Plant (Control Buildings).

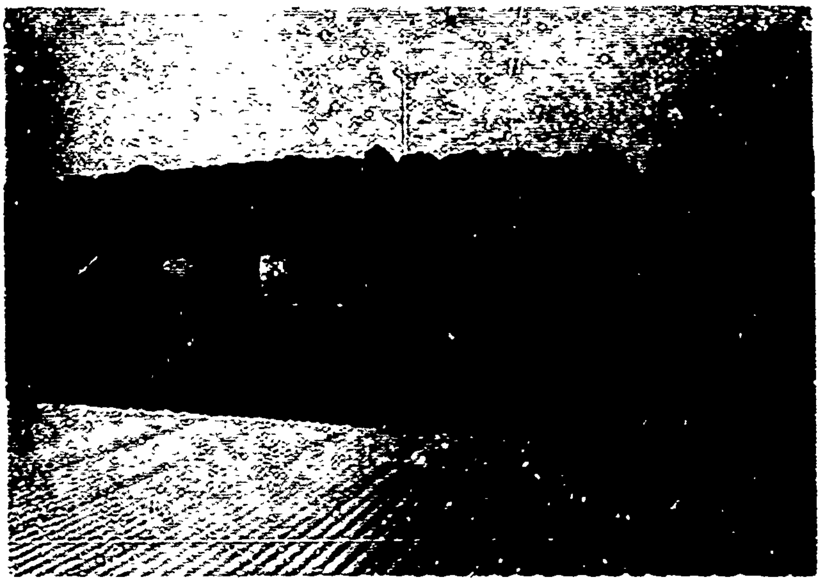

Fig. B-9c. Waste-Water Treatment Plant (Sludge Tanks).

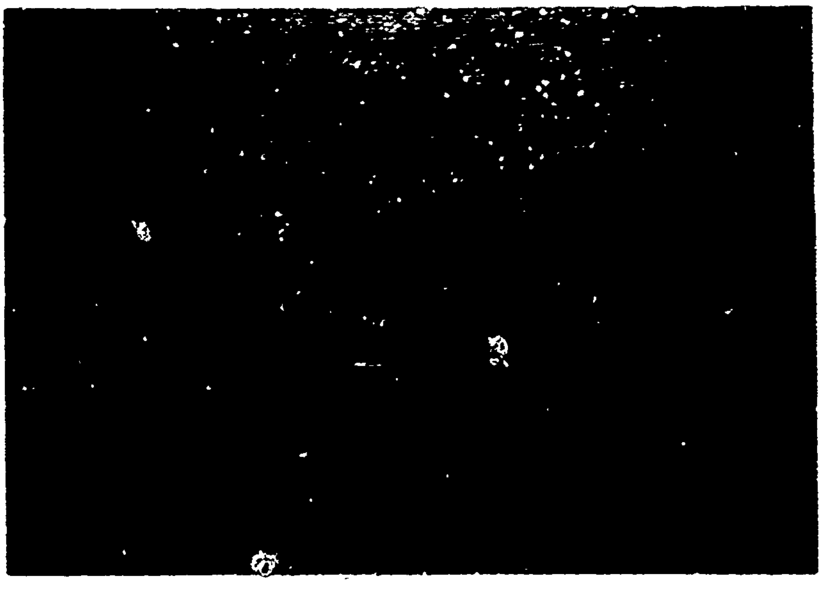

Fig. B-9d. Waste-Water Treatment Plant (Office and General Laboratory).

horizontal plane of approximately 200 feet in extent before encountering structures, albeit of insufficient mass and size to provide significant mutual shielding. One exception to this is a small block structure approximately 15 feet in height, which is approximately 60 feet from the rear of the facility in question.

9. <u>Waste-Water Treatment Plant, Ann Arbor, Michigan</u>

The Waste-Water Treatment Plant of Ann Arbor is a facility composed of several structures as may be seen in the photographs of the facility. Fig. B-9a is a north view of the facility and shows components of the facility which were chosen as important for consideration in decontamination analyses. In the center of the photograph is a large structure behind which are a number of smaller buildings. The large structure in the left center is the machinery building for the facility. The two structures just beyond the machinery building are control buildings. At the far right, partially obscured by a low tree, is the office and general laboratory building for the facility. A second view of the machinery building and the two control buildings is shown in Fig. B-9b (the structures at the far rear are blower and final chlorination buildings and are not essential for operation). The structures chosen for analysis in this study were the machinery building, the second control building behind the machinery building, and the office and laboratory building. Fig. B-9c shows the sludge tanks and sidewalk adjacent and control building. Fig B-9d is a picture of the office and general laboratory building.

The office and general laboratory building is a two-story structure, 56x31 feet in dimension. It has a very heavy roof and second-story floor, and medium heavy exterior walls. The control building chosen for analysis is 18x42 feet in dimension, one story in height, with a very heavy roof, and medium heavy exterior walls. The machinery building is a combination one- and two-story structure. The two-story part was analyzed, and this part measures 37x53 feet. It is constructed with medium heavy walls, and very heavy roof and second-story floor. The area surrounding all of these buildings is either paved driveway, open pits (e.g., sludge tanks), or grassy lawns. The buildings are close enough together to form mutual shields in many cases, but the separate components of the facility are individually quite small with the exception of the machinery building and its immediately adjacent structures, and the mutual shielding provided is therefore limited. Spacing between the buildings ranges between 150 and 200 feet, but is not

important since the intervening area is primarily composed of aeration or sludge tanks which do not permit collection of fallout on their surfaces.

10. City of Detroit Water Works

The City of Detroit Water Works consists of a series of structures of medium heavy to very heavy construction. The individual structures considered to be critical to the operation of the water works are the high lift, the low lift, the general laboratory building, and the chlorination building. These structures are individually considered in the following discussion. Surrounding all of the structures is an open grassy area. Some of the structures are mutually shielded as shown by their orientation in the plot plan of the facility (Fig. B-10a). However, since most of the construction is extremely heavy masonry, mutual shielding has little effect in most cases on the dose rate received inside the structures.

The high lift building is shown in front and side view in the Figs. B-10b and B-10c. This facility is of such extremely massive construction that decontamination is not required for safe operation of its contained machinery. In some places, the walls are approximately 10 feet thick concrete, brick, and stone; and over the entire structure are a minimum of two feet thick with the exception of the doors and windows. In addition to this, all of the operating machinery is located below grade; thus except for the small amount of radiation which might be received through the heavy roof of the structure, little decontamination would be required for the protection of personnel working within the building.

The low lift building is shown in the next set of photographs (Figs. B-10d and B-10c). The exterior shot illustrates the mutual shielding that is afforded the low lift building, the structure on the left, by the filter building. The interior photograph shows the machinery within the low lift building, which is similar in layout and organization to that in the high lift. This structure has a medium weight roof and very heavy wall construction, and is afforded mutual shielding on the north end by a small structure and on the east by the filter building.

The third structure in the Detroit Water Works included in this study is the laboratory building which is on the north side of the filter building (Fig. B-10f). This is a four story building that has a heavy roof and floor construction and very heavy exterior walls. The structure is mutually shielded by the adjacent filter building; however, the upper stories of the laboratory building are exposed to fallout deposited on the roof of the filter building. Except for this, the construction is similar in nature to that of the previously described structures in the facility.

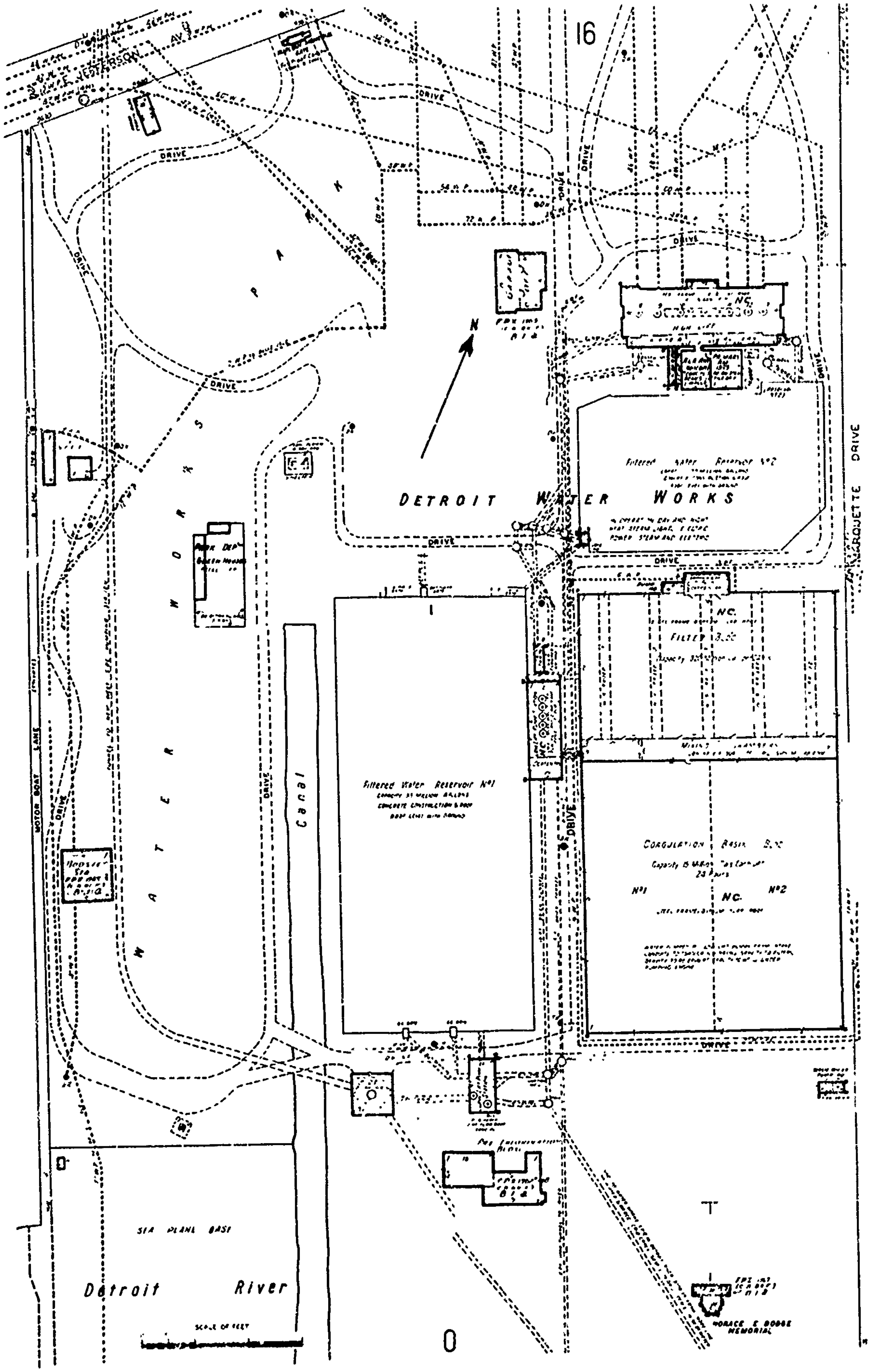

Fig. B-10a. City of Detroit Water Works (Plot Plan).

Fig. B-10b. City of Detroit Water Works
High Lift Building (Front View).

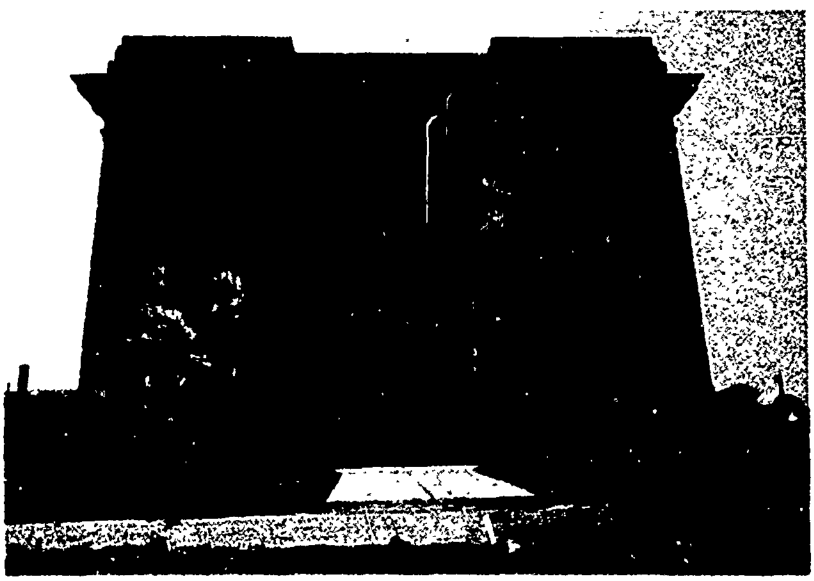

Fig. B-10c. City of Detroit Water Works
High Lift Building (Side View).

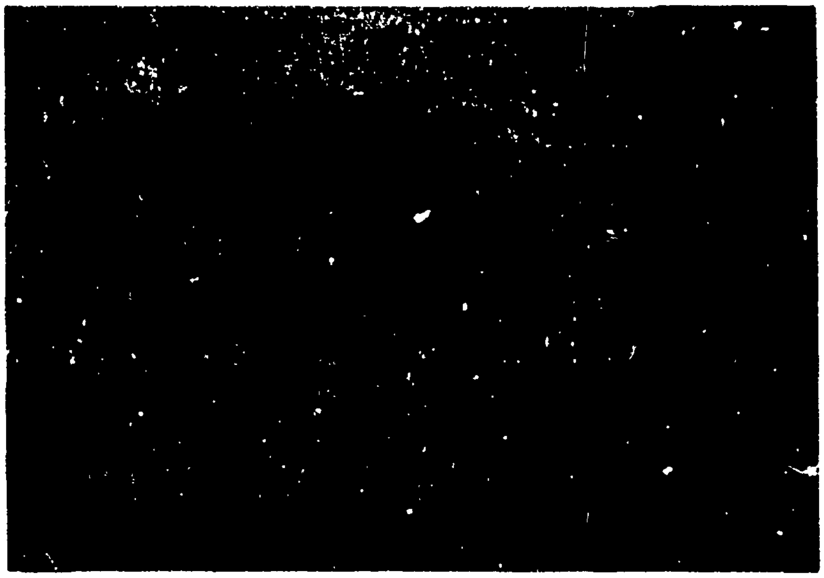

Fig. B-10d. City of Detroit Water Works
Low Lift Building (Exterior).

Fig. B-10e. City of Detroit Water Works
Low Lift Building (Interior).

The remaining structure analyzed in the Detroit Water Works is the pre-chlorination building (Fig. B-10g). This is a single story building with very heavy roof and medium heavy walls. It is mutually shielded by a low lift pump station structure located approximately 60 feet behind the structure in the view shown in the photograph (this low lift pump station can be seen over the top of the pre-chlorination building). Except for this mutual shield, the area surrounding this structure, as in a case of all the other structures, is a horizontal, grassy surface.

11. Michigan State Police Headquarters

As shown in Figs. B-11a--B-11c, this structure consists of three separate parts, two of which are two stories in height, and one of which is a single story garage structure. The two story portions have light roofs and floors and medium heavy exterior walls. The garage portion has medium heavy exterior walls, but has nearly 100 percent apertures on two sides (the one shown in the Fig. B-11c and the one opposite that shown). The roof of this part is also very light. The area surrounding the facility consists of paved parking lots and streets for the most part with a limited grassy area in front of the facility.

12. Roseville Police Headquarters, Roseville, Michigan

This facility consists of a sprawling one-story structure of medium weight walls and very light roof. The police headquarters has a core section which is 84x84 feet in dimension. Facing the front of the building, there is a 24-foot extension from this section to the right; this projection is approximately 39 feet deep. Figures B-12a and B-12b show the front of the structure. Figure B-12c shows the right rear view, including the 24x39-foot projection (at the left in the photograph). The facility is built adjacent to a municipal court building and garage building which act as a mutual shield to the structure in question (this adjacent building is at the left in Fig. B-12b, and at the right in B-12c). Surrounding the facility is a large open area that consists of about half grass and half paved parking lot or street. As can be seen in the photographs, the front of the building is largely windows. The other sides of the building, with the exception of the 24x39-foot projection, are largely solid wall.

13. Roseville Fire Department Headquarters, Roseville, Michigan

This facility is a compound structure consisting of a one-story office and living quarters building, 39 feet wide by 109 feet deep, of 12-foot height, and a garage building, 65 feet wide by 92 feet deep and 15 feet high. The walls of both parts are medium heavy and the roofs are very light. The general layout

Fig. B-10f. City of Detroit Water Works
Filter Building.

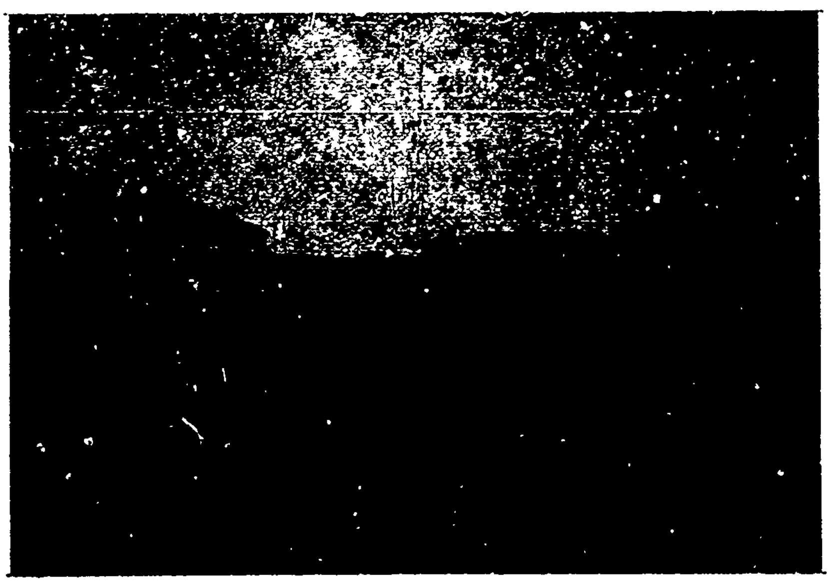

Fig. B-10g. City of Detroit Water Works
Pre-Chlorination Building.

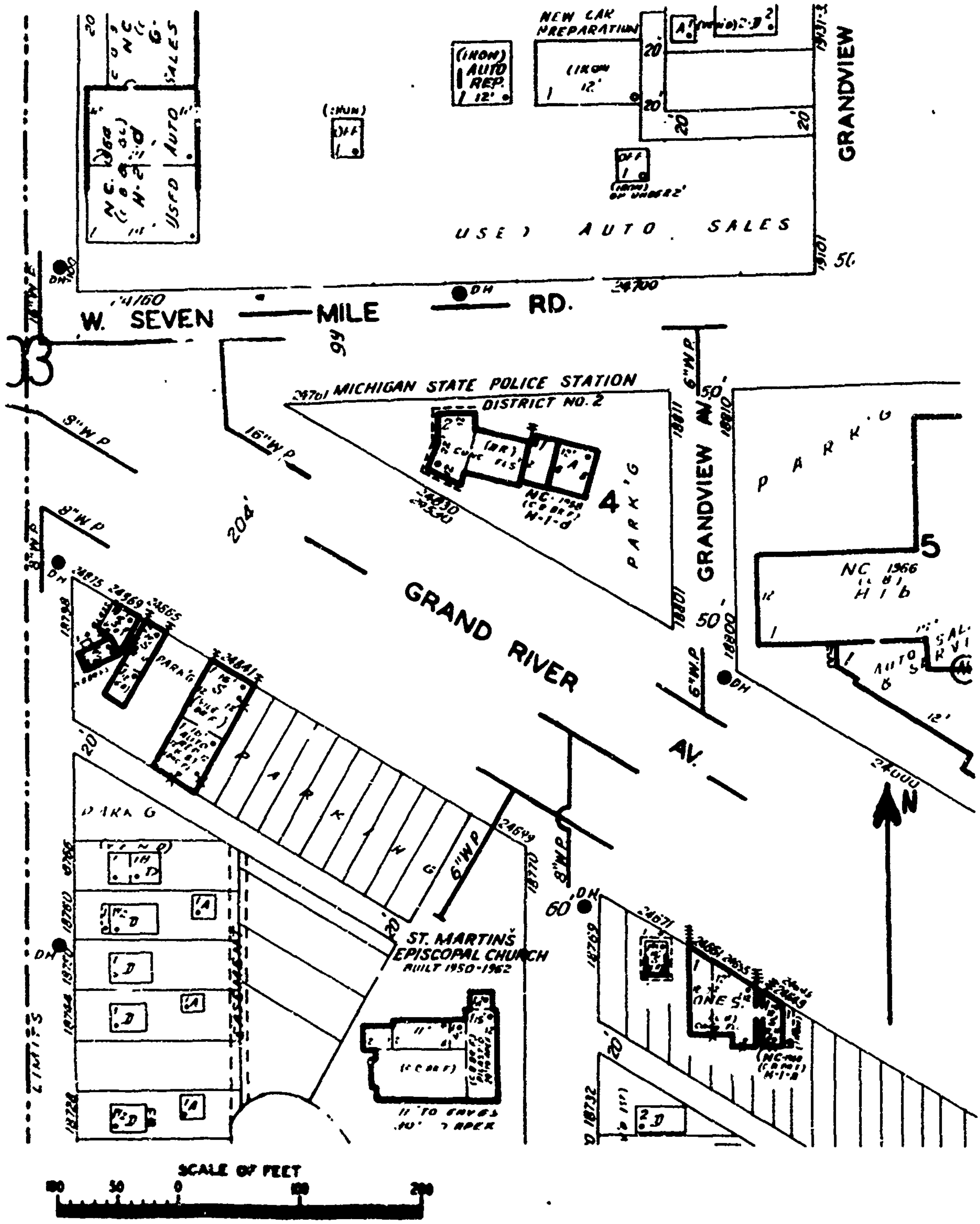

Fig. B-11a. Michigan State Police Headquarters (Plot Plan).

Fig. B-11b. Michigan State Police Headquarters.

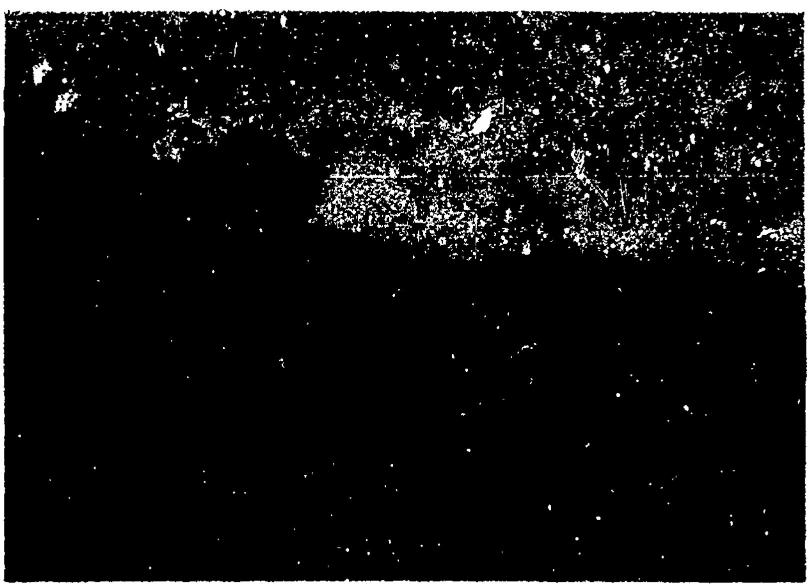

Fig. B-11c. Michigan State Police Headquarters.

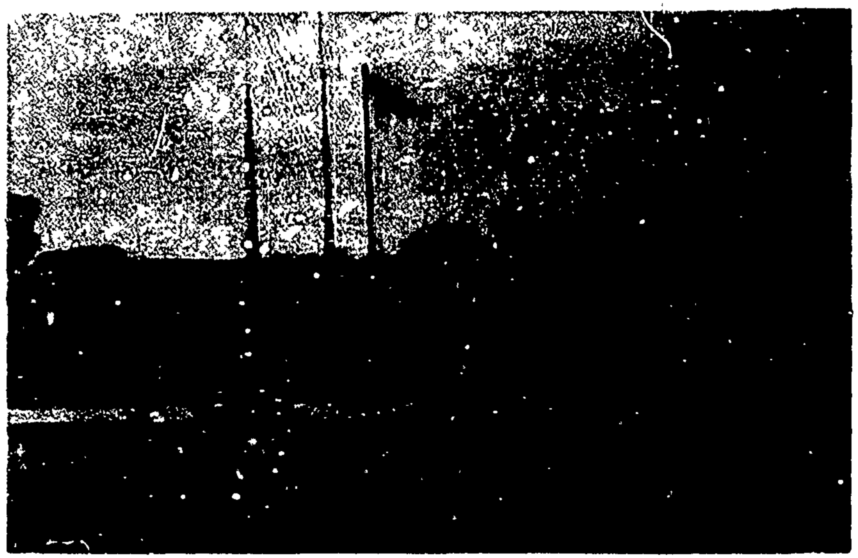

Fig. B-12a. Roseville Police Headquarters (Front View).

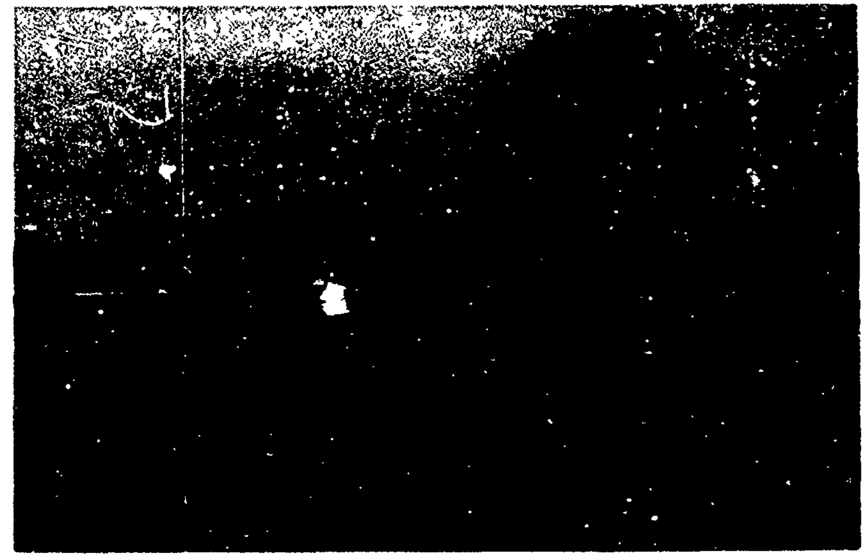

Fig. B-12b. Roseville Police Headquarters (Front View).

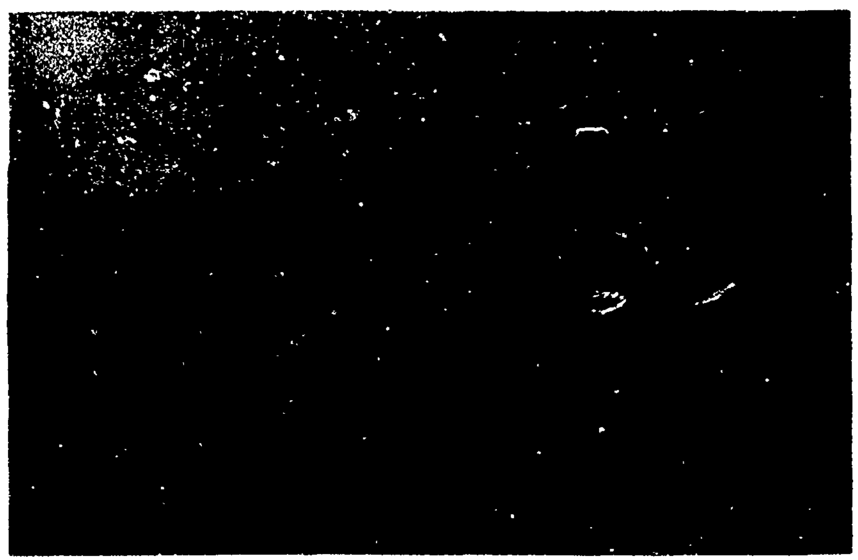

Fig. B-12c. Roseville Police Headquarters (Right Rear View).

of the facility is seen in the photograph (Fig. B-13). It is located in a horizontal plane and has concrete aprons front and rear with horizontal grassy areas or gravel surfaces past the concrete slabs. The planes are open front and rear to a minimum of 400 feet and to a minimum of 60 feet on the left of the view shown in the photograph, and 200 feet on the right of that view. Left and right of the facility are buildings of very light construction which afford little or no mutual shielding to the facility. The entire facility must be decontaminated for operational effectiveness in a fallout situation.

14. The Lingeman School in Detroit

As shown in the photograph and the plot plan (Figs. B-14a and B-14b), the Lingeman school is a three-storied structure with heavy walls, light roof, and medium weight floors. It is surrounded on the north, west, and south sides by graveled playground areas, and on the east side by a small grassy area and a paved street. The other facilities in the area are of very light construction and afford little or no mutual shielding. In order to use the school for emergency medical and housing purposes, the entire area should be decontaminated. No one special part of the structure has preference over any other. The annex building shown in the plot plan is approximately 15 feet high and does afford some mutual shielding to the structure; however, in view of its relatively small size, the effects are minimal.

15. Hale School, Riverview, Michigan

This structure is of irregular shape, one story in height, of medium heavy wall weight, and medium roof weight (Fig. B-15a). It is surrounded by essentially an infinite plane of either paved or grass play and lawn area. The structure has a few small peripheral buildings which afford some mutual shielding, but primary mutual shielding comes from other parts of the facility itself.

Any attempt to utilize a structure of this type for emergency medical or housing purposes in a post nuclear attack situation would necessarily presage a consideration of all surrounding areas as potential source planes. There are no special characteristics to the facility with the exception of the covered walkway shown in the background of the view in Fig. B-15b. The walkway extends from the rear of the building (to the right in the photograph) to the front portion of the structure, a very small portion of which is visible at the left of the photograph. The overall facility is very irregular in shape, but has maximum dimensions in the wing shown to the right in Fig. B-15b of 240 feet by 117 feet. The portion of the structure to which the covered

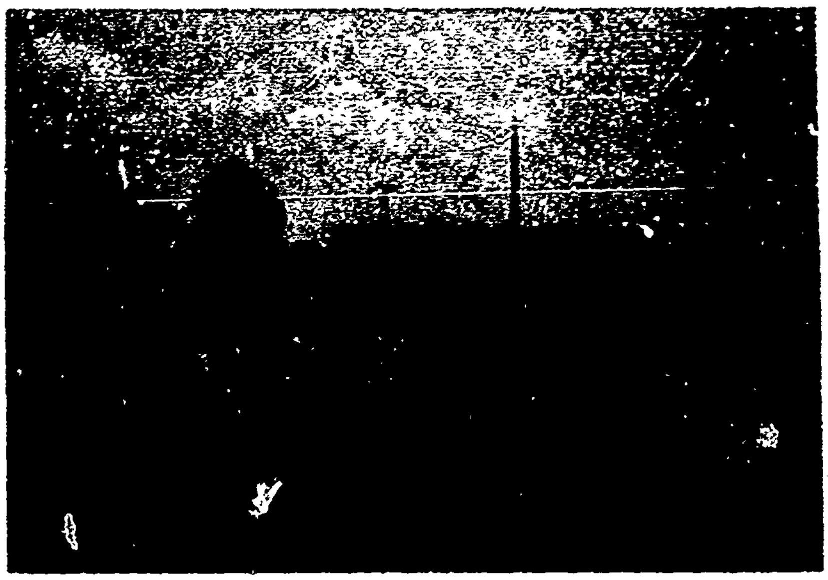

Fig. B-13. Roseville Fire Department Headquarters.

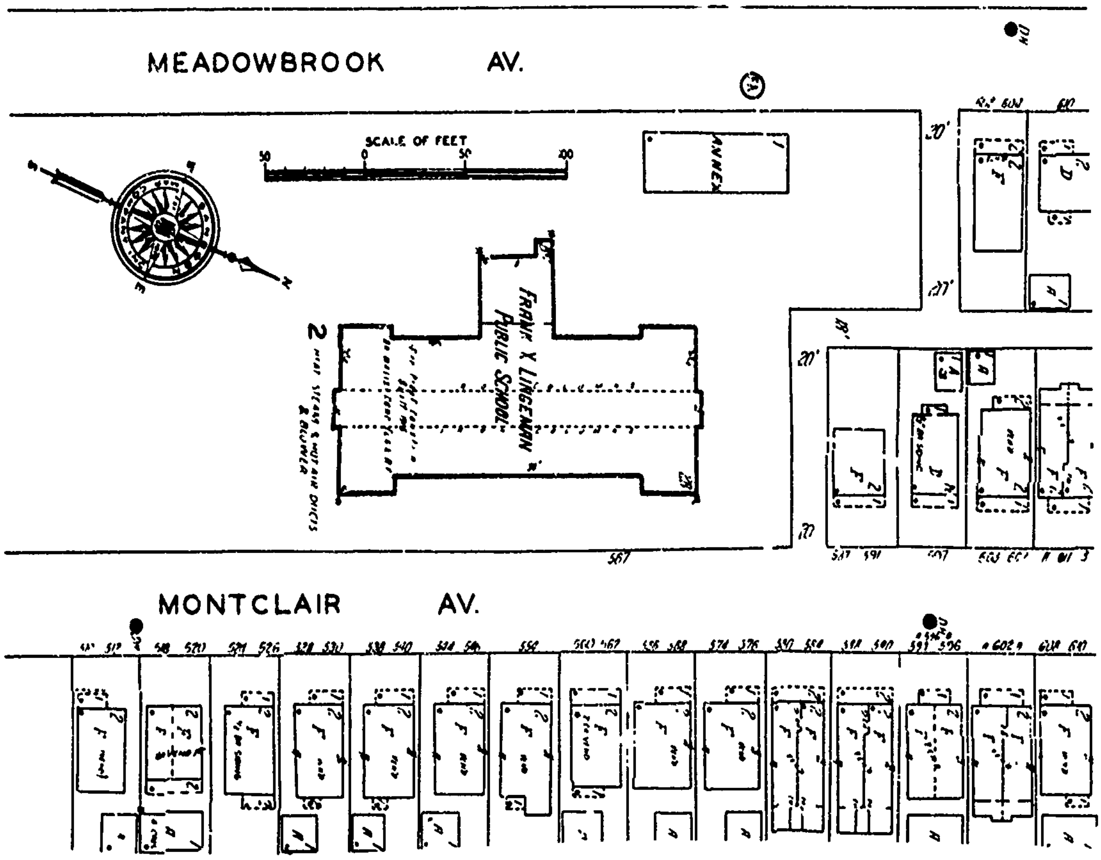

Fig. B-14a. The Lingeman School (Plot Plan).

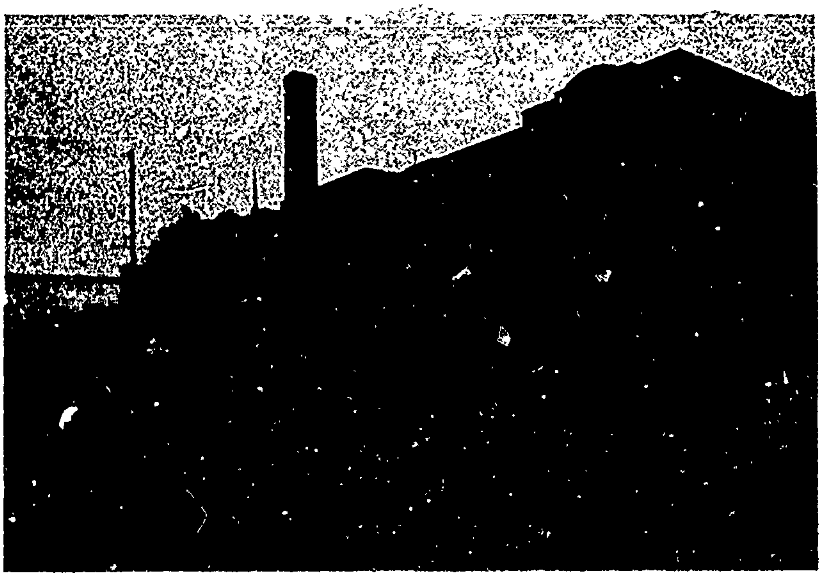

Fig. B-14b. The Lingeman School.

Fig. B-15a. Hale School (Front View).

Fig. B-15b. Hale School (Covered Walkway).

walkway is adjacent is 300 feet by 48 feet wide. The remaining portion of the structure, shown in the foreground of Figure B-15a, is approximately 80x120 feet in dimension. The height of the structure is approximately 18 feet. These dimensions are all extremely rough since there are many irregularities to the actual building shape; however, they do serve to give an idea of the size of the structure involved.

16. Municipal Building in Roseville, Michigan

As can be seen from the plot plan and the photographs of this facility (Figs. B-16a--B-16c), it is an unusually shaped structure, consisting of a two-story office area, 24 feet in height; and a one-story garage and auxiliary area, 14 feet in height. The structure has medium heavy exterior walls and light roof and floors. It is surrounded by large, open planes and has one mutually shielding building on the north side approximately 100 feet distant from the facility in question. On the south side of the structure are some light frame buildings, approximately 100 feet away, and on the west side are some light, commercial structures approximately 150 feet distant. The east side of the structure is open for at least 300 feet. The surrounding areas are primarily paved surfaces with a few grassy areas as shown in the photographs. There is no preferential portion of the building from a decontamination standpoint and if the structure were to be utilized in a postattack situation, decontamination of the area surrounding the entire facility would probably be required.

17. Roseville DPW and Water Building

As shown in the photographs (Figs. B-17a and B-17b), this facility consists of a central office space surrounded by several garage structures. The exterior wall construction is of medium weight and the roof is of light construction. The office area is approximately 13 feet high; the garage structures are 20 to 25 feet high. The primary thing of interest in this facility is in the surrounding planes. All of these areas consist of unpaved, gravel surfaces, used primarily for refuse disposal truck parking and emergency public works vehicles. This facility would have to have its garage space and office area operational in a postattack situation if it were to be functional. It is of note that the decontamination of an area such as this would be particularly difficult, because of the high porosity of the surrounding surface area, unless piling or grading techniques were used. There are no other special properties about the structure. It is of shell construction similar to the garage service facilities of many public works departments. The surrounding planes are

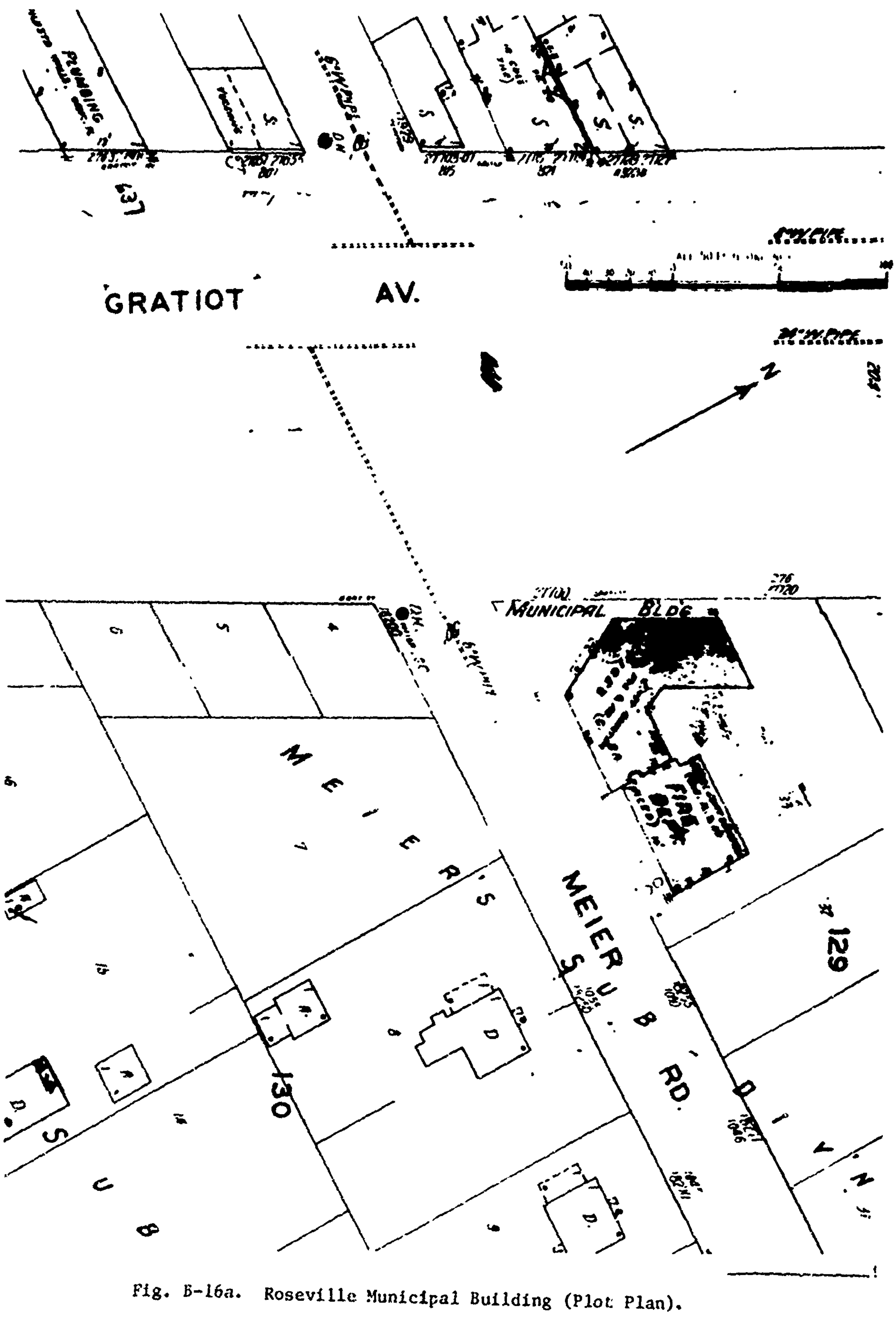

Fig. B-16a. Roseville Municipal Building (Plot Plan).

Fig. B-16b. Roseville Municipal Building Office Area.

Fig. B-16c. Roseville Municipal Building
Garage and Auxiliary Area.

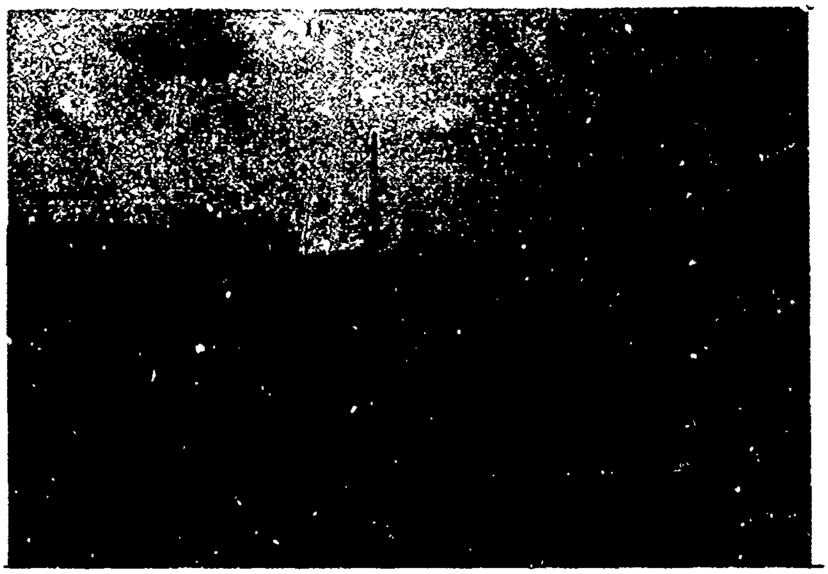

Fig. B-17a. Roseville DPW and Water Building (Front View).

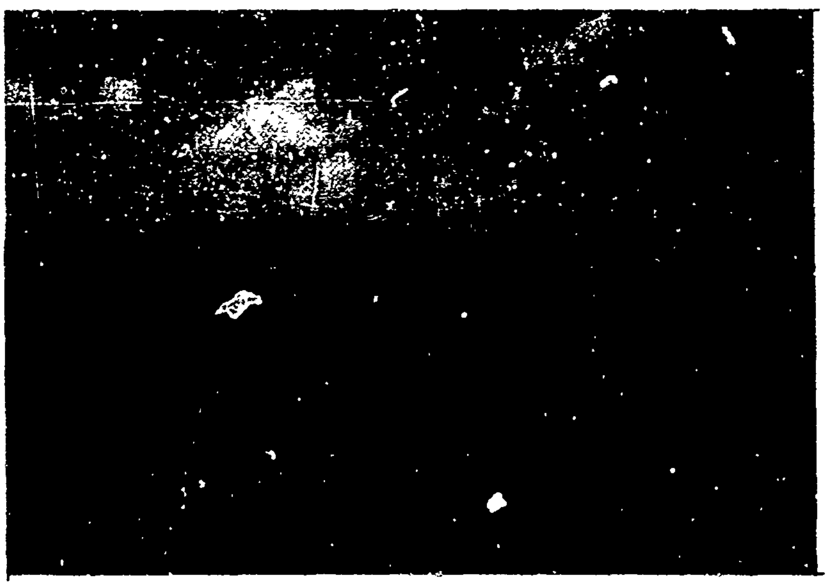

Fig. B-17b. Roseville DPW and Water Building (Right Rear View).

essentially infinite in extent and the only mutual shielding afforded in the facility is that provided by the different parts of the structure.

18/19. <u>The Kroger Food Store and the Detroit Bank and Trust Company, both located in the Northland Center Shopping Complex</u>*

The Kroger Food Store is Facility Number 12 in this complex, and as shown in the plot plan and photographs (Figs. B-18/19a--B-18/19c), is an integral portion of a larger structure. The facility is bounded on the southeast side by an extremely large parking area, and on the opposite (northwest) side by a partially covered mall. The walls of these two sides are virtually all glass or equally light material. The adjacent structures on the two remaining sides have fairly light walls, but do afford some mutual shielding. The roof of the structure is of very heavy construction and about 18 feet high.

The Detroit Bank is Facility Number 1 in the plot plan, and as shown in the photograph (Fig. B-18/19d) has a construction very similar to that of the Kroger Food Store. This facility, however, is bounded on two adjacent sides (northwest and northeast) by an extremely large parking area, and by mutually shielding facilities on the other two sides. Again, the walls of the structure are virtually all glass, or equivalent (from a shielding standpoint), and the roof is very heavy and approximately 18 feet high.

As can be noted from the photographs, the mall is partially covered between the various facilities in the shopping complex and the walkways peripheral to the structure are also covered by a heavy canopy. This canopy is approximately 15 feet high and 15 feet wide around all facilities in the complex.

20. <u>Detroit Metropolitan Wayne County Airport</u>

As shown in the aerial photograph (Fig. B-20a), this facility consists of a large complex of structures surrounded by essentially infinite fields of potential fallout contamination. The surrounding areas are partially grassed, and partially paved. The only mutual shielding afforded the facility is by different structures and parts of structures within the complex itself. The portions of the facility chosen for study were the main terminal building (Fig. B-20b), and the central service building (left center; Fig. B-20c). These two structures, as shown in the photographs, have large window areas; however, except for window area the structures have medium heavy to very heavy external walls, and have very heavy roof and floor construction.

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* These facilities are described together here since they are part of the same complex even though they fall in different priorities for decontamination (Cf. Table VII, page 35).

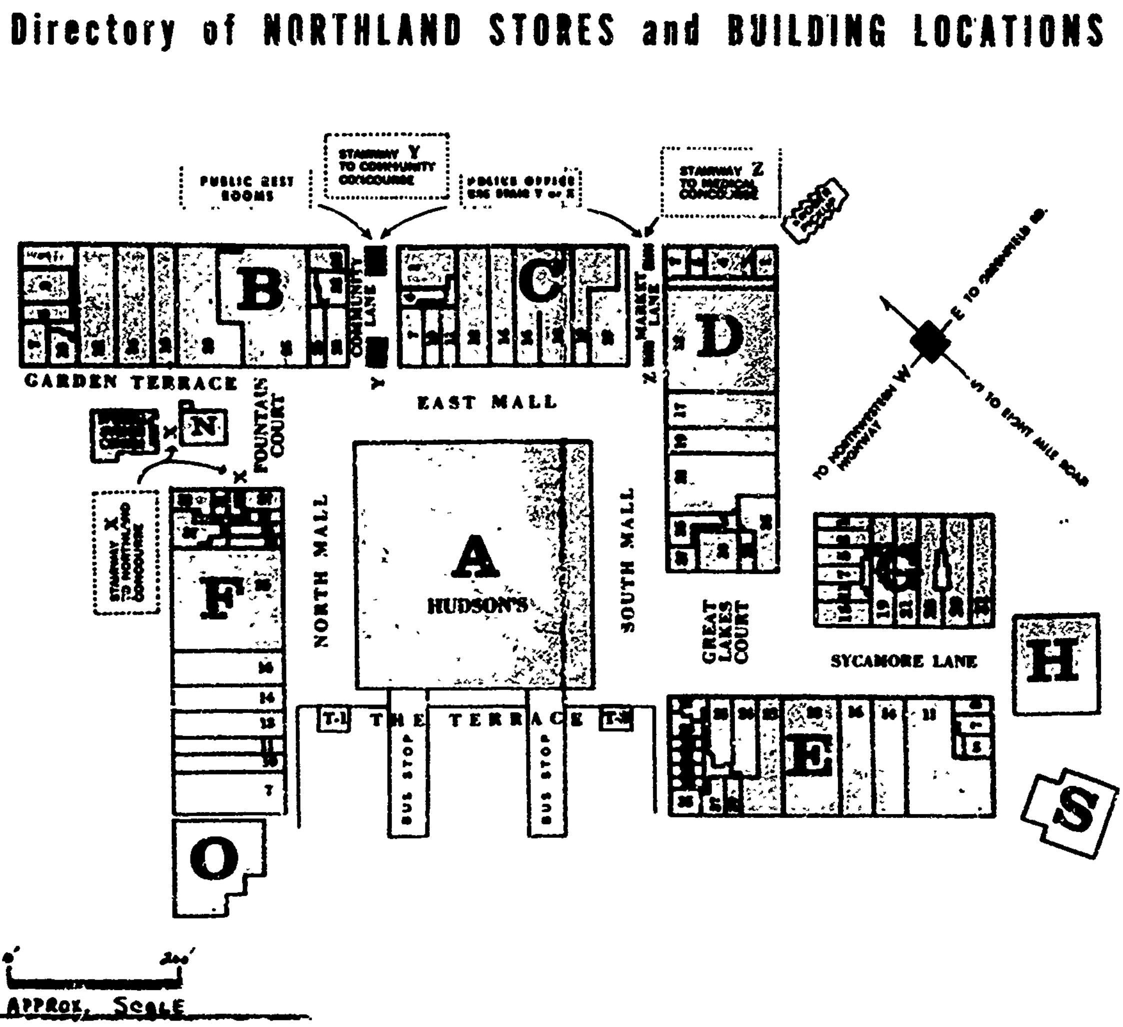

Fig. B-18/19a. Northland Center Shopping Complex (Plot Plan).

Fig. B-18/19b. The Kroger Food Store (Front View).

Fig. B-18/19c. The Kroger Food Store and Parking Area.

Fig. B-18/19d. The Detroit Bank and Parking Area.

Fig. B-20a. Detroit Metropolitan Wayne County Airport (Aerial View).

Fig. B-20b. Detroit Metropolitan Wayne County Airport Main Terminal Building.

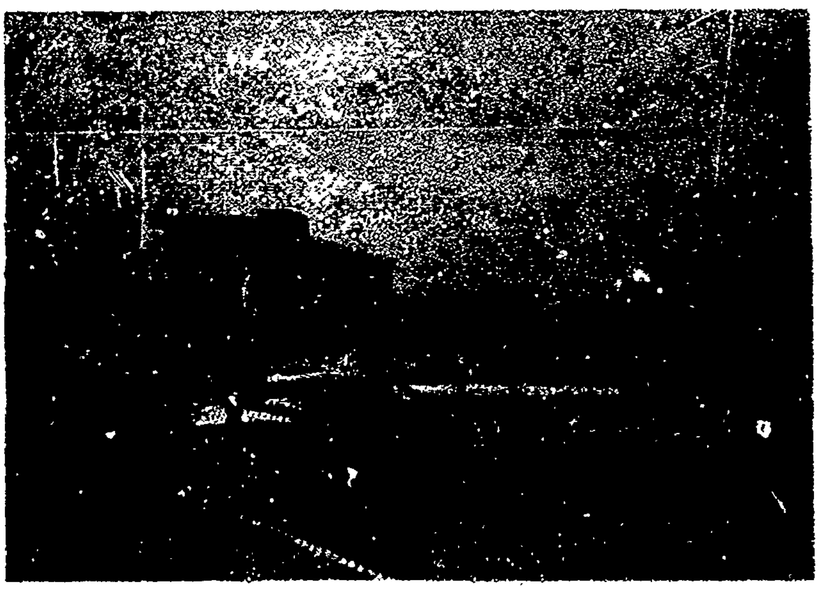

Fig. B-20c. Detroit Metropolitan Wayne County Airport Central Service Building.

The main terminal building has two stories above the grade shown in Fig. B-20b, and has a control tower atop the structure. The structure also has a story below the grade shown opening at grade level on the landing strip side. There is an entrance at this lower grade level on the parking area side. This lower floor is assumed to be the first floor of the structure. The height of the structure is approximately 45 feet above the grade shown in Fig. B-20b, excluding the tower. It measures approximately 200x400 feet, excluding concourse areas.

The central service building is a six story, approximately 78 feet tall facility. This building measures approximately 130x330 feet. As shown in the picture (Fig. B-20c), this building has solid end walls and a large aperture fraction, front and rear.

The special characteristics of the airport facility consist of the extremely large and complex areas required for land vehicle and aircraft parking, and the very wide expanse of windows within the facility buildings themselves. In a postattack situation the entire drive and parking area adjacent to the structures of interest must be decontaminated for safe operation. Also, the aircraft docking areas and loading facilities must be decontaminated. Since landing and take-off operations blow a considerable amount of debris around the area, operation of the facility of this type would also necessitate essentially complete clean-up of the entire runway and airplane parking area.

21. <u>Detroit Bolt and Nut Company</u>

This facility consists of a large one-story structure. The front portion of the building (approximately 145x84 feet deep) is office area, approximately 12 feet in height (Fig. B-21a). Behind this is a loading dock area, approximately 145x163 feet and 16 feet in height (Figs. B-21b, B-21c and B-21d). Behind this area is the wider, rear section, of the structure, approximately 231x603 feet, and 16 feet in height (Fig. B-21b). The walls of the structure are medium heavy and the roof is very light. The unusual characteristic of this building is shown in the photographs. It consists of a completely covered loading dock with a ramp leading into this area (there is a second loading dock similar in nature but of smaller width further to the rear of the structure). In order for this facility to be operational, not only would the planes surrounding the facility have to be decontaminated, but effort would have to be made to keep the covered dock areas fallout-free.

Fig. B-21a. Detroit Bolt and Nut Company (Office Area).

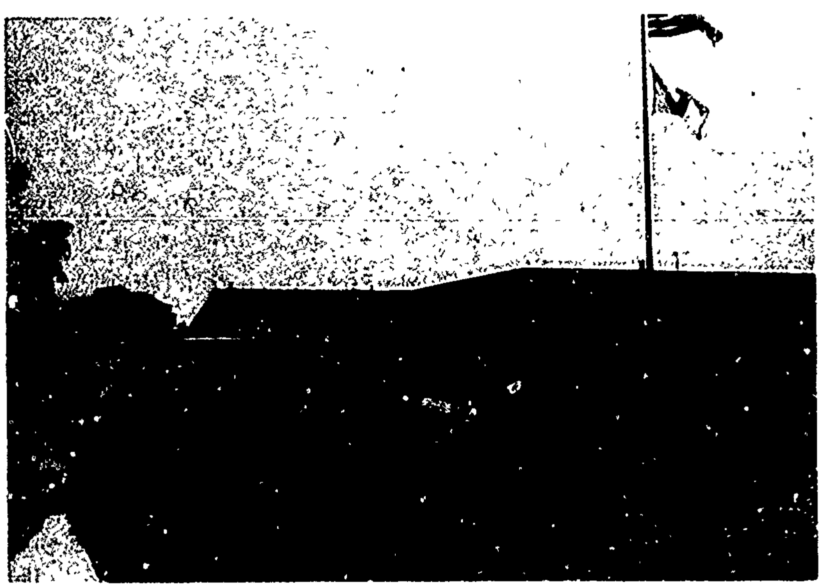

Fig. B-21b. Detroit Bolt and Nut Company (Loading Area and Rear Section).

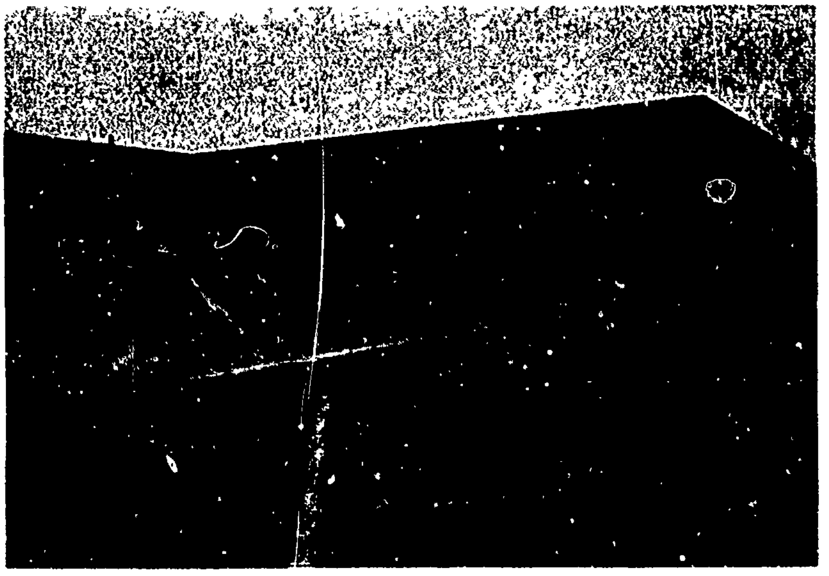

Fig. B-21c. Detroit Bolt and Nut Company (Ramp).

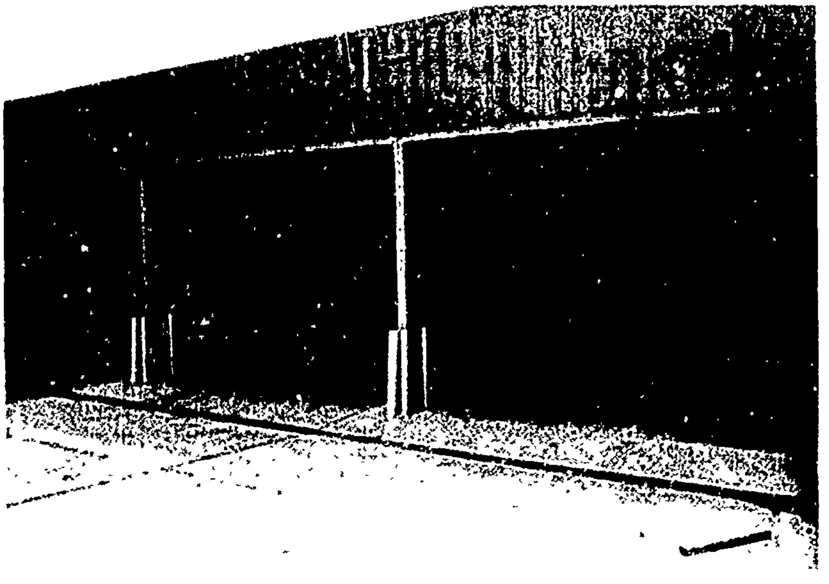

Fig. B-21d. Detroit Bolt and Nut Company
Covered Loading Dock

Surrounding this facility are mostly parking and grassed areas. A mutually shielding building extends along the front and loading dock areas of the facility approximately 40 feet from the side of the structure opposite that shown in Fig. B-21b. At the rear of the facility is a storage building at approximately 105 feet distant which also acts as a mutual shield. Notwithstanding these other structures, the greatest portion of the surrounding area is essentially an infinite field.

22. The Detroit Artillery Armory

This facility is an extremely large one- and two-story structure. The floor plan has a large rectangular area with a relatively small "T" shaped section extending from the center of one long side. The large rectangular portion of the structure is approximately 470x1050 feet, and 20 to 28 feet in height. This portion of the structure is shown at the left in Fig. B-22a. The smaller front portion of the facility (at the right in Fig. B-22a) is approximately 45x440 feet in plan dimension, 25 feet in height. This portion is offset from the larger structure by a part approximately 135 feet long by 25 feet wide, 25 feet high (right center, Fig. B-22a). Figure B-22a is a side on view of the west side facility; Fig. B-22b shows the view from the southeast quadrant. Figure B-22c shows the rear of the facility, partially shielded by a light corrugated metal structure. This last view indicates the size of structure and the nature of its surroundings. The front "T" shaped portion of the structure is built of medium weight walls and roof, and very heavy floors. The rear part of the building has a medium weight roof and exterior walls. The only significant mutual shielding afforded in the facility is by different parts of the facility itself and as can be vaguely seen by the photographs, the principal characteristics of the structure are its extremely large size and the large gravel and grassy areas surrounding it.

Fig. B-22a. The Detroit Artillery Armory (West Side View).

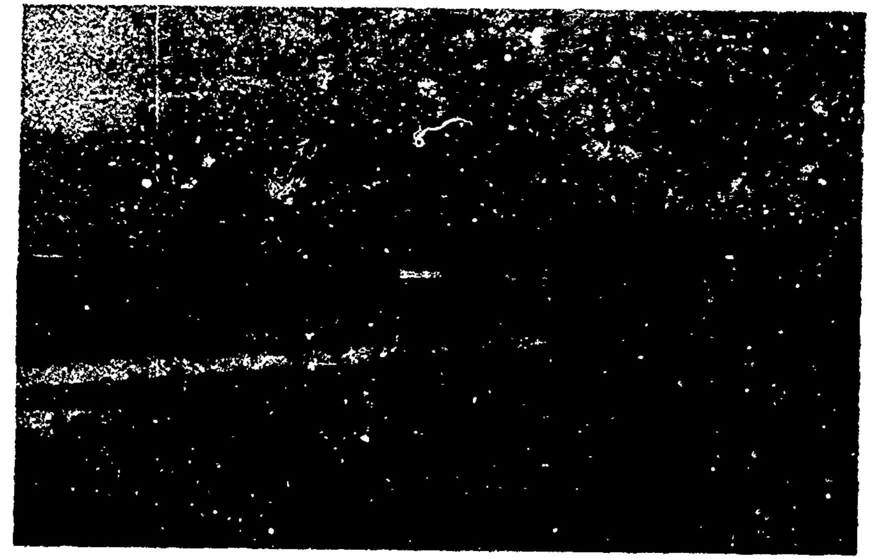

Fig. B-22b. The Detroit Artillery Armory View from Southeast Quadrant.

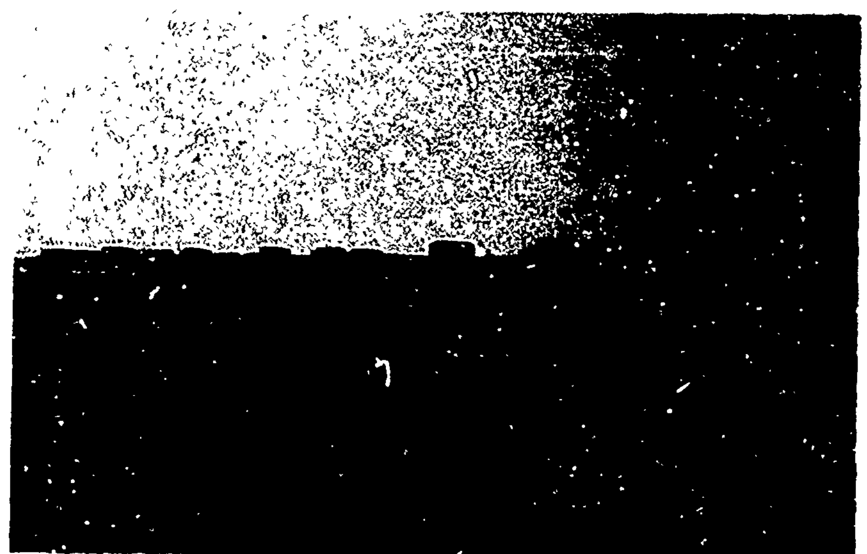

Fig. B-22c. The Detroit Artillery Armory (Rear View).

Appendix C

Decontamination Analyses of Detroit Facilities

Appendix C

Decontamination Analyses of Detroit Facilities*

The facilities included in the Detroit Survey made under this contract were subjected to analyses of the dose rates received at a central detector location within various parts of the structures comprising the facilities (a structural part is considered to be a portion of a building which can be described by a rectangular floor plan; this is the technique utilized in the description of a facility to the NFSS/PF-COMP Computer Program[17/]). The PF-COMP Computer Program, which utilizes Engineering Manual Techniques, was employed to calculate the contribution to detectors located at the center and three feet above the various floors of the structures studied. This technique, which is reasonably accurate for large contaminated fields and roof sources, served to indicate the sources of the most important contributions to the various detector locations. Table C-I indicates for each of the facilities studied the relative importance of roof to ground sources.

The PF-COMP Computer Program was further utilized to analyze the relative ground contribution from each plane outside the facilities being investigated. Using these results, an identification was made of the most significant ground planes contributing to the dose rate at the various detector locations. These significant sources were further utilized in determining the effectiveness of decontamination of a facility as a function of the width (measured perpendicular to the wall) of the contaminated plane exterior to the wall.

The characteristics of these planes and the associated walls were coded for analyses by the CONSTRIP V Computer Program. The method of analys. was to describe the source planes in rectangular geometry with rectangular subdivisions specified. This particular format was chosen so that general conclusions could be reached concerning the effectiveness of limited strip decontamination with a minimum number of unknown parametric effects due to unusual source geometries. In the analysis of the source planes for the facilities studied there are generally five equal width strips parallel to the wall and three corridors extending outward from the wall. The wall itself defines the base of the central corridor which in turn is flanked by a corridor of equal width on both sides. In the cases where this was not possible or desirable because the external plane was bounded by one or more mutually shielding structures, special consideration was given and

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* Cf. Table VII, page 35.

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Table C-I

RELATIVE CENTER DETECTOR LOCATION CONTRIBUTION
IN DETROIT SURVEY FACILITIES

Facility	No. of Stories	Story No.	C_c	C_g
ST. JOHN HOSPITAL				
Right Wing	7	1	0.0	0.0206
		2	0.0	0.0143
		3	0.0	0.0092
		4	0.0004	0.0074
		5	0.0019	0.0063
		6	0.0019	0.0072
		7	0.0415	0.0062
Right Section of Front Wing	7	1	0.0	0.0035
		2	0.0	0.0114
		3	0.0	0.0090
		4	0.0005	0.0074
		5	0.0019	0.0071
		6	0.0081	0.0082
		7	0.0579	0.0078
Center Wing	7	1	0.0	0.0028
		2	0.0	0.0117
		3	0.0	0.0065
		4	0.0005	0.0037
		5	0.0020	0.0035
		6	0.0082	0.0050
		7	0.0408	0.0046
Left Wing	6	1	0.0007	0.2827
		2	0.0027	0.0886
		3	0.0165	0.0557
		4	0.0320	0.0433
		5	0.0940	0.0323
		6	0.2636	0.0249
USPHS HOSPITAL				
Front Wing	3	1	0.0025	0.0302
		2	0.0094	0.0221
		3	0.0394	0.0177
Right Front Wing	3	1	0.0031	0.0200
		2	0.0121	0.0309
		3	0.0397	0.0161
Central Wing	4	1	0.0098	0.0017
		2	0.0134	0.0076
		3	0.0207	0.0072
		4	0.0386	0.0072
Right Rear Wing	4	1	0.0004	0.0251
		2	0.0024	0.0452
		3	0.0095	0.0362
		4	0.0474	0.0289

(Continued)

Table C-I (Continued)

Facility	No. of Stories	Story No.	C_o	C_g
Left Rear Wing	4	1	0.0004	0.0215
		2	0.0023	0.0455
		3	0.0094	0.0398
		4	0.0464	0.0333
Left Front Wing (section close to center)	4	1	0.0004	0.0107
		2	0.0019	0.0166
		3	0.0076	0.0118
		4	0.0362	0.0098
Left Front Wing (end section)	4	1	0.0010	0.0337
		2	0.0034	0.05[illegible]
		3	0.0126	0.0[illegible]
		4	0.0825	0.0401
PROVIDENCE HOSPITAL				
Right Half of Front Wing	6	1	0.0000	0.0146
		2	0.0010	0.0152
		3	0.0005	0.0144
		4	0.0023	0.0122
		5	0.0093	0.0101
		6	0.0470	0.0095
Core Section with Loading Dock	3	1	0.0021	0.0027
		2	0.0126	0.0035
		3	0.0405	0.0146
Special Loading Dock Subsection	4	0	0.0040	0.0025
		1	0.0083	0.0134
		2	0.0084	0.0122
		3	0.0381	0.0218
Emergency Entrance Section	3	1	0.1583	0.0162
		2	0.0348	0.0166
		3	0.2281	0.0098
MISTERSKY POWER STATION				
Left Front Section	1	1	0.0347	0.0053
Right Section	1	1	0.0785	0.0032
Left Rear Section	1	1	0.0480	0.0166
FERMI ATOMIC POWER PLANT	1	1	0.0403	0.0753
WXYZ RADIO AND TV				
Rear Section	2	1	0.0374	0.0266
		2	0.1652	0.0121
Center Section	3	1	0.0366	0.0101
		2	0.1522	0.0126
		3	0.1676	0.0196
Front Section	1	1	0.1419	0.0258

(Continued)

Table C-I (Continued)

Facility	No. of Stories	Story No.	C_o	C_g
MICHIGAN BELL, Lahser Rd.	3	1	0.0128	0.0177
		2	0.0360	0.0140
		3	0.0837	0.0113
MICHIGAN BELL, Van Dyke	3	1	0.0012	0.0032
		2	0.0065	0.0046
		3	0.0431	0.0037
WASTE-WATER PLANT				
Office	2	1	0.0035	0.0407
		2	0.0444	0.0382
Control 1	1	1	0.0336	0.0379
Machinery, end toward tanks	2	1	0.0335	0.0315
		2	0.0606	0.0169
Machinery, end away from tanks	2	1	0.0106	0.0264
		2	0.0507	0.0167
DETROIT WATER WORKS				
Low-Lift	1	1	0.1317	0.0222
High-Lift	1	1	0.0451	0.0233
Laboratory	4	1	0.0034	0.0415
		2	0.0098	0.0203
		3	0.0331	0.0135
		4	0.1327	0.0235
Pre-chlorination	1	1	0.0546	0.0542
MICHIGAN STATE POLICE				
Front Section	2	1	0.0935	0.0365
		2	0.2214	0.1254
Center Section	2	1	0.1092	0.1089
		2	0.2270	0.1554
Rear Section	1	1	0.2414	0.1819
ROSEVILLE POLICE				
Garage Section	1	1	0.1829	0.1552
Main Section	1	1	0.1673	0.0919
Wing to Right of Main Section	1	1	0.1419	0.1795

(Continued)

Table C-I (Continued)

Facility	No. of Stories	Story No.	C_o	C_g
ROSEVILLE FIRE DEPT.				
Main Section	1	1	0.2138	0.0429
Garage Section	1	1	0.1918	0.1008
LINGEMAN SCHOOL	3	B	0.0628	0.0356
		1	0.1195	0.0184
		2	0.2795	0.0227
HALE SCHOOL				
Left Center Section	1	1	0.2546	0.0327
Left Front Section	1	1	0.2309	0.0347
ROSEVILLE MUNICIPAL BUILDING	3	B	0.0611	0.0229
		1	0.0775	0.0625
		2	0.1869	0.0853
ROSEVILLE DPW & WATER				
Right Front Section	1	1	0.1115	0.2101
Front of Center Section	1	1	0.3036	0.0759
Left Front Section	1	1	0.2356	0.0829
KROGER STORE	1	1	0.0189	0.0530
WAYNE MAJOR AIRPORT				
Central Service	6	1	0.0	0.1763
		2	0.0	0.0325
		3	0.0002	0.0206
		4	0.0012	0.0130
		5	0.0065	0.0103
		6	0.0432	0.0086
Terminal Building	3	1	0.0384	0.1076
		2	0.0154	0.0581
		Tower	0.0312	0.0486
DETROIT BOLT & NUT CO.				
Office Area	1	1	0.3851	0.0763
Loading Dock Area	2	B	0.3109	0.0110
		1	0.3586	0.0567
Main Area Back to Loading Dock	1	1	0.4953	0.0152

(Continued)

Table C-I (Continued)

Facility	No. of Stories	Story No.	C_o	C_g
Main Area Opposite Loading Dock	1	1	0.3164	0.0253
Back Area	1	1	0.3170	0.0170
DETROIT ARTILLERY ARMORY				
Right Front Corner of Main Section	1	1	0.2788	0.0167
Right Center Part of Main Section	2	1	0.0302	0.0089
		2	0.2291	0.0128
Right Wing of Front Section	2	1	0.0246	0.0678
		2	0.2525	0.0295
Left Rear Corner of Main Section	1	1	0.2927	0.0056
DETROIT BANK & TRUST	1	1	0.0169	0.0257

these cases were analyzed separately. In all calculations the detector locations described in the CONSTRIP V Computer Analyses corresponded to the central detector location of the PF-COMP analyses.

The data from the PF-COMP and the CONSTRIP analyses were combined to produce a study of the effectiveness of limited strip decontamination. For planes of essentially infinite extent the radiation from the plane as given by the PF-COMP calculations were taken as the total ground contribution from that plane. Decontamination effectiveness was determined by utilizing the CONSTRIP V Program to calculate the dose rate from each of the fifteen patches (five strips times three corridors) external to the wall. It was assumed that fallout was removed completely from each patch in succession moving outward from the wall. The percentage of the radiation remaining after decontamination in this fashion was then determined. The results of these analyses for first floor detector locations are presented in Tables C-IIa and C-IIb. Shown is the percentage of the contribution from the wall being studied after decontamination to the contribution originally passing through that wall. Also shown is the percentage of the original dose rate radiation through the barrier being studied to the total original dose rate at the detector position (this indicates the importance of the source field under consideration). Parameters of the barrier and source planes are also given.

In the case of walls exposed to limited contaminated planes (those planes which have mutually shielding buildings or other natural obstructions bounding them), it was found that the PF-COMP Computer Program produced total radiation predictions which were significantly smaller in many cases than those calculated by the CONSTRIP V Program.* As a result the contribution for the entire plane calculated by the CONSTRIP Program was taken to be the total contribution for the decontamination effectiveness analyses. The PF-COMP calculations were still used as a guide to the relative importance of the contribution from the limited plane.†

Table C-IIa shows the residual contribution through the barrier in question to the initial contribution through that barrier considering that the corridor centered on the barrier wall has been completely cleared of fallout contamination to the limit of the contaminated plane. The residual dose comes from the wing

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* Limited planes, for purposes of discussion, have been assumed to extend no further than 200 feet perpendicular to the wall in question; planes with greater width have been assumed infinite.

† Sky shine was not included in the PF-COMP calculations since much of it arises from sources beyond the limited areas under consideration.

Table C-IIa

LIMITED PLANE DECONTAMINATION PARAMETERS

Facility	Important Barrier[1/]	Barrier PSF	Wall Length (ft)	Field Width (ft)	Barrier [2/] Building %C	Residual Barrier[3/] %C
FIRST PRIORITY: (1)[4/] MEDICAL						
St. John Hospital	Left Wall of Right Wing	175	117.5	80	2.3	1.1
	Right Wall of Center Wing	175	117.5	80	3.8	1.1
	Left Wall of Center Wing	175	117.5	80	3.5	1.1
USPHS Hospital	Rear Wall of Front Wing	70	112	30.9	4.3	22.9
	Rear Wall of Left Front Wing	70	86	70	12.8	12.1
	Front Wall of Left Rear Wing	70	73[5/]	80	13.9	4.5
	End Wall of Left Rear Wing	70	28	100	4.7	23.1
	Rear Wall of Right Front Wing	70	86	70	11.6	12.1
Providence Hospital	Loading Dock Wall	99	45	60	38.5	0.6
	(2) POWER AND COMMUNICATION					
Fermi Reactor Power Plant	Wall of Operations Building Facing Away from Reactor	5	176	7	1.2	0
WXYZ Radio and Television Station	Rear Wall	85	150	100	11.3	0.6
Michigan Bell Exchange Lahser Rd.	Front Wall	108	82	75	4.1	22.7
	Left Wall	108	180	40	3.8	4.2
	(3) WATER AND SEWAGE TREATMENT					
Waste-Water Treatment Plant, Ann Arbor	Wall of Machinery Building Facing Tanks	100	57	40	23.0	5.3

(continued)

Table C-IIa (Continued)

Facility	Important Barrier 1/	Barrier PSF	Wall Length (ft)	Field Width (ft)	Barrier Building 2/ %C	Residual Barrier 3/ %C
City of Detroit Water Works	Low-Lift Pump Building, Wall Facing Filter Building	160	180	40	3.5	0.6
	Pre-Chlorination Building, Left Wall of Right Section	91	39	60	5.0	10.3
(5) EMERGENCY MEDICAL AND HOUSING						
Hale School	Right Wall of Left Rear Section	91	105	153	1.6	0
SECOND PRIORITY: (1) GOVERNMENT BUILDINGS						
Roseville DPW and Water Building	Left Wall of Right Wing	51	43	93	2.5	25.4
THIRD PRIORITY						
Detroit Artillery Armory	Rear Wall of Right Front Wing	60	207	135	23.8	0.7

1/ The barriers and building parts are described as though the observer were facing the building from the street or address side.

2/ The % C Barrier/Building column gives the original percentage contribution of the ground dose rate through the wall barrier to the original total dose rate received by the detector.

3/ The % C Residual/Barrier column gives the residual dose rate contribution after decontamination through the wall barrier as a percentage of the original dose rate through the wall. The decontaminated area is a rectangular corridor on the ground bounded by the edge of the wall and extending perpendicular to the wall to the boundry of the source plane.

4/ The number in parentheses () indicates the category of the facility as shown in Table VII, Facilities in the Detroit Survey.

5/ The triangular shape of this particular source plane requires two strips 73 feet wide, one 60 feet wide, and one 48 feet wide.

corridor(s) of the plane (those to either side of the central corridor). The size of the corridor width (the wall length) and the field width (the distance perpendicular to the wall to limit of the contaminated plane) are also indicated. The contributions shown in all cases in Table C-IIa are those from the ground source exterior to the wall barrier.

Table C-IIb shows similar information to that in Table C-IIa, except that here infinite plane and roof sources are considered for the structures involved. For wall barriers, the contribution indicated is that from the external ground source. In the case of roof barriers, only roof sources are assumed in the analyses. The residual percentage contribution through wall barriers after decontamination are shown in Table C-IIb along with the distance cleared perpendicular to the barriers in the central corridors. For roof sources the entire roof is assumed to be left free of fallout after clean up procedures have been carried out. In calculations of dose rates from roof sources, the barrier mass thickness used is the total intervening mass thickness between source and detector.

The results of these calculations were analyzed in various ways as described below to find relationships between the various parameters involved. In all of the analyses, the distance cleared refers to the distance the corridor directly adjacent the wall is cleared in a direction perpendicular to the wall. The wing corridors generally have been found to give a small to insignificant percentage contribution to the total dose entering through a wall. Therefore, the analyses (shown in Tables C-IIa and C-IIb) have been limited to the decontamination efforts aimed first at that portion of the plane directly opposite a given barrier.

Analyses were performed of the relation between distance cleared out from the wall and the percentage of total contribution still entering through the wall after clearing. These analyses were done for five wall thickness categories: 0 to 19 psf, 20 to 39 psf, 40 to 79 psf, 80 to 119 psf, 120 to 159 psf, and 160 psf or more. It was clear from the analyses that barriers could be divided into two categories, namely those facing essentially infinite planes, and those facing limited planes of contamination. Wall weights had no effect on percentage of residual dose rate after central corridor decontamination. The two general categories are discussed in the following.

A. Walls Facing Infinite Planes of Contamination

Figure C-1 indicates a lack of correlation between percentage of residual dose rate after partial decontamination of infinite planes as a function of distance cleared in the central corridor. In the analyses which produced this figure, the wall mass thickness of each of the barriers was also considered as described above. Other parameters investigated included the wall height, wall length, and building shape (the ratio of the wall length to the perpendicular distance from the wall to the detector location). No significant correlation was found with any of these parameters to the effectiveness of limited strip decontamination of central corridor areas adjoining wall barriers.

It should be noted, however, that in most cases investigated, the roof contribution is still the most significant of all contributions arriving at the detector location for the facilities in which the detector is located within three floors of the roof source. Therefore, as yet no generalized guidelines can be given for limited strip decontamination operations of infinite field ground sources. However, it can be safely stated that roof sources are often the most significant and should be given highest priority for facilities to be occupied within three floors of the roof source.

B. Walls Facing Limited Planes

Analyses similar to those discussed above for the infinite plane cases were conducted for wall barriers adjacent limited source planes. As mentioned above, the CONSTRIP V total dose predictions were utilized here as the basis for determining the residual percentage contribution through a wall barrier as a function of the distance cleared perpendicular to the barrier. In all cases, the analyses assumed only the central corridor to be decontaminated. Wing corridors were found to make varying amounts of contributions through the wall barriers depending upon wall thickness and geometrical configuration of the source area. The Figs. C-2a through C-2d indicate the percentage residual contributions through various wall barriers as a function of the percent of the central corridor cleared. Clearing is assumed to start and move outward from the barrier and to take place uniformly across the entire corridor, i.e., the fallout is removed in strips parallel to the wall. These analyses were separated into four groups according to the width of the limited plane of contamination: 0 to 49.9 feet; 50 to 74.9 feet; 75 to 99.9 feet; and 100 feet or more. As can be seen from the figures, decontamination of 100 percent of the central corridor generally produces a reduction of ground contribution through the wall barrier by 90 percent or more. The exceptions to this are for wall barriers in which the ratio of the length of the wall to the perpendicular detector distance

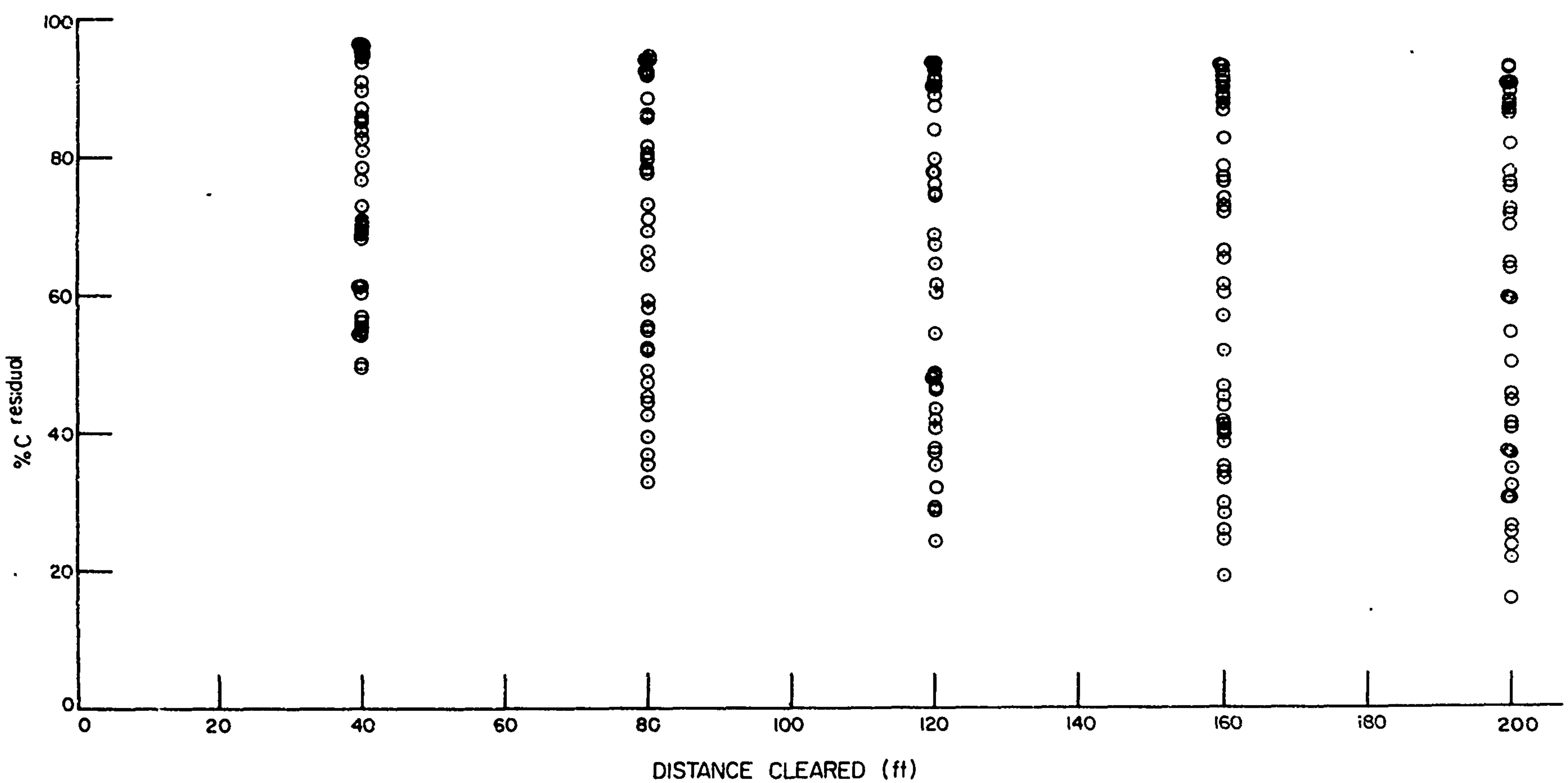

Fig. C-1. Infinite Plane Residual Ground Contribution.

Table C-IIb

INFINITE PLANE AND ROOF DECONTAMINATION PARAMETERS

Facility	Important Barrier[1]	Barrier PSF[2]	Wall Length (ft)	Roof Area (ft^2)	Barrier Building[3] %C	Residual Barrier[4] %C	Distance Cleared (Feet)
FIRST PRIORITY: (1)[5] MEDICAL							
St. John Hospital	Right Wall of Right Wing	175	117.5		3.0	15.6	200
USPHS Hospital	Front Wall of Front Wing	70	112		19.1	0[6]	200
	Roof of Front Wing	106		4928	5.2	0	
	Roof of Left Front Wing	154		3916	4.2	0	
	Roof of Left Rear Wing	202		2044	0.6	0	
	Right Wall of Right Front Wing End	70	90		22.0	21.4	200
Providence Hospital	End Wall of Right Front Section	99	60		11.3	63.9	200
	Front Wall of Right Front Section	99	132		18.4	34.0	250
	Rear Wall of Loading Dock Section	99	42		23.0	81.1	200
	Roof of Loading Dock Section	193		1890	6.5	0	
(2) POWER AND COMMUNICATION							
Mistersky Power Station	Left Wall of Boiler Section	160	192		19.3	87.4	200
	Roof of Boiler Section	30		14060	64.3	0	
Fermi Atomic Power Station	Wall away from Water	5	176		27.8	30.1	200
	Roof	3		30380	25.1	0	
WXYZ Radio and Television	Left Wall of Rear Section	85	150		19.5	69.4	200
	Roof of Rear Section	77		27000	55.6	0	
Michigan Bell Exchange, Van Dyke and Whipple	Roof	216		22464	8.9	0	

(Continued)

Table C-IIb (Continued)

Facility	Important Barrier 1/	Barrier PSF 2/	Wall Length (ft)	Roof Area (ft^2)	Barrier Building 3/ %C	Residual Barrier 4/ %C	Distance Cleared (Feet)
Michigan Bell Exchange, Lahser Rd.	Rear Wall	108	82		6.7	54.0	200
	Roof	114		14760	25.8	0	
	(3) WATER AND SEWAGE TREATMENT						
Waste-Water Plant, Ann Arbor	Front Wall, Office/Laboratory	100	56		23.6	39.9	200
	Right Wall, Office/Laboratory	100	31		12.0	58.9	200
	Roof, Office/Laboratory	170		1736	5.4	0	
	Long Wall, Control Building	100	42		23.5	43.9	200
	Roof, Control Building	70		756	35.4	0	
	Roof, Machinery Building	140		2960	28.1	0	
City of Detroit Water Works	Rear Wall, Low-Lift Building	160	65		2.7	92.1	200
	Right Wall, Low-Lift Building	160	180		4.2	71.8	200
	Roof, Low-Lift Building	20		11700	77.5	0	
	Left Wall, Laboratory Building	160	42		12.5	90.1	200
	Front Wall, Laboratory Building	160	88		62.1	92.4	200
	Roof, Laboratory Building	150		1760	7.1	0	
	Front Wall, High-Lift Pump Building	490	295		9.9	90.0	200
	Roof, High-Lift Pump Building	45		31270	79.3	0	
	Rear Wall, Pre-Chlorination Building	91	97		11.4	25.1	200
	Right Wall, Pre-Chlorination Building	91	64		9.0	63.1	200
	Roof, Pre-Chlorination Building	60		6208	54.8	0	

(Continued)

Table C-IIb (Continued)

Facility	Important Barrier[1/]	Barrier PSF[2/]	Wall Length (ft)	Roof Area (ft^2)	Barrier Building[3/] %C	Residual Barrier[4/] %C	Distance Cleared (Feet)
	(4) FIRE AND POLICE FACILITIES						
Michigan State Police Headquarters	Front Wall of Front Section	91	51		7.7	36.7	200
	Right Side Wall of Front Section	91	42		6.2	44.9	200
	Roof of Front Section	7		2142	53.5	0	
	Left Wall of [illegible] Section	0	72		19.1	23.2	200
	Roof of Rear Section	5		3672	55.0	0	
Roseville Police Headquarters	Front Wall, Main Section	73	84		18.8	75.7	200
	Rear Wall, Main Section	73	45.5		7.4	77.1	200
	Roof, Main Section	19		6804	60.9	0	
Roseville Fire Department Headquarters	Front Wall, Office Section	91	39		5.8	85.5	200
	Left Wall, Office Section	91	109		7.6	31.8	200
	Roof, Office Section	13		4251	79.9	0	
	Front Wall, Garage Section	0	65		14.7	30.0	200
	Rear Wall, Garage Section	0	65		12.2	26.0	200
	Right Wall, Garage Section	91	92		5.2	49.5	200
	Roof, Garage Section	13		5980	61.5	0	
	(5) EMERGENCY MEDICAL AND HOUSING						
Lingeman School	Left End Wall	120	70		1.9	90.1	200
	Roof	30		12320	74.6	0	
Hale School	Left Wall, Left Rear Section	91	105		7.4	71.0	200
	Roof, Left Rear Section	10		9345	82.9	0	
SECOND PRIORITY:	**(1) GOVERNMENT BUILDINGS**						
Roseville Municipal Building	Front Wall	83	32		10.3	86.0	200
	Right Wall	83	50		18.2	74.9	200
	Roof	8		1600	49.6	0	

(Continued)

Table C-IIb (Continued)

Facility	Important Barrier[1/]	Barrier PSF[2/]	Wall Length (ft)	Roof Area (ft^2)	Barrier Building[3/] %C	Residual Barrier[4/] %C	Distance Cleared (Feet)
Roseville DPW and Water	Front Wall, Center Section	51	93		11.7	0[6/]	200
	Roof, Center Section	10		6696	77.0	0	
	Left Wall, Rear Section	51	93		7.3	58.9	200
	Rear Wall, Rear Section	51	131		9.5	40.7	200
	Roof, Rear Section	10		12183	71.2	0	
	(2) FOOD DISTRIBUTION						
Kroger Food Store	Front Wall	0	120		46.4	36.8	200
	Roof and Canopies	96		18360	19.4	0	
	(3) TRANSPORTATION FACILITIES						
Detroit Metropolitan Wayne County Airport	Central Service Building, Rear Wall	91	300		43.5	88.7	200
	Terminal Building, Rear Wall	0	450		21.2	86.7	200
	Terminal Building, Roof	150		9000	18.0	0	
THIRD PRIORITY							
Detroit Bolt and Nut Company	Right Wall of Manufacturing Section	91	465		1.2	34.3	200
	Roof of Manufacturing Section	4		107415	95.5	0	
Detroit Artillery Armo.	Rear Wall, Rear Left Corner Section	60	275		1.7	0[6/]	200
	Roof, Rear Left Corner Section	11		79200	96.0	0	
Detroit Bank and Trust Co.	Front Wall	0	70		43.0	0[6/]	200
	Right Wall	0	30		15.0	0[6/]	200
	Roof and Canopies	96		3150	28.3	0	

(Continued)

Table C-IIb (Continued)

1/ The barriers and building parts are described as though the observer were facing the building from the street or address side.

2/ The Barrier PSF for roofs of multi-story buildings includes the weight in PSF of intervening floors.

3/ The % C Barrier/Building column gives the original percentage contribution of the dose rate through the barrier to the original total dose rate received by the detector.

4/ The % C Residual/Barrier column gives the residual dose rate contribution after decontamination through the barrier as a percentage of the original dose rate through the wall. The decontaminated area is a corridor on the ground bounded by the edge of the wall and extending perpendicular to the wall to the bounding distance cleared as shown in the last column of the table. For roofs, the entire roof is assumed cleared.

5/ See Footnote 4 in Table C-IIa.

6/ In this case, CONSTRIP analysis indicated a slightly larger contribution from a 200-foot wide strip than did PF-COMP for the infinite field. This is due to round-off error in the PF-COMP analysis. Therefore, CONSTRIP was assumed to give the infinite field contribution in the 200-foot analysis.

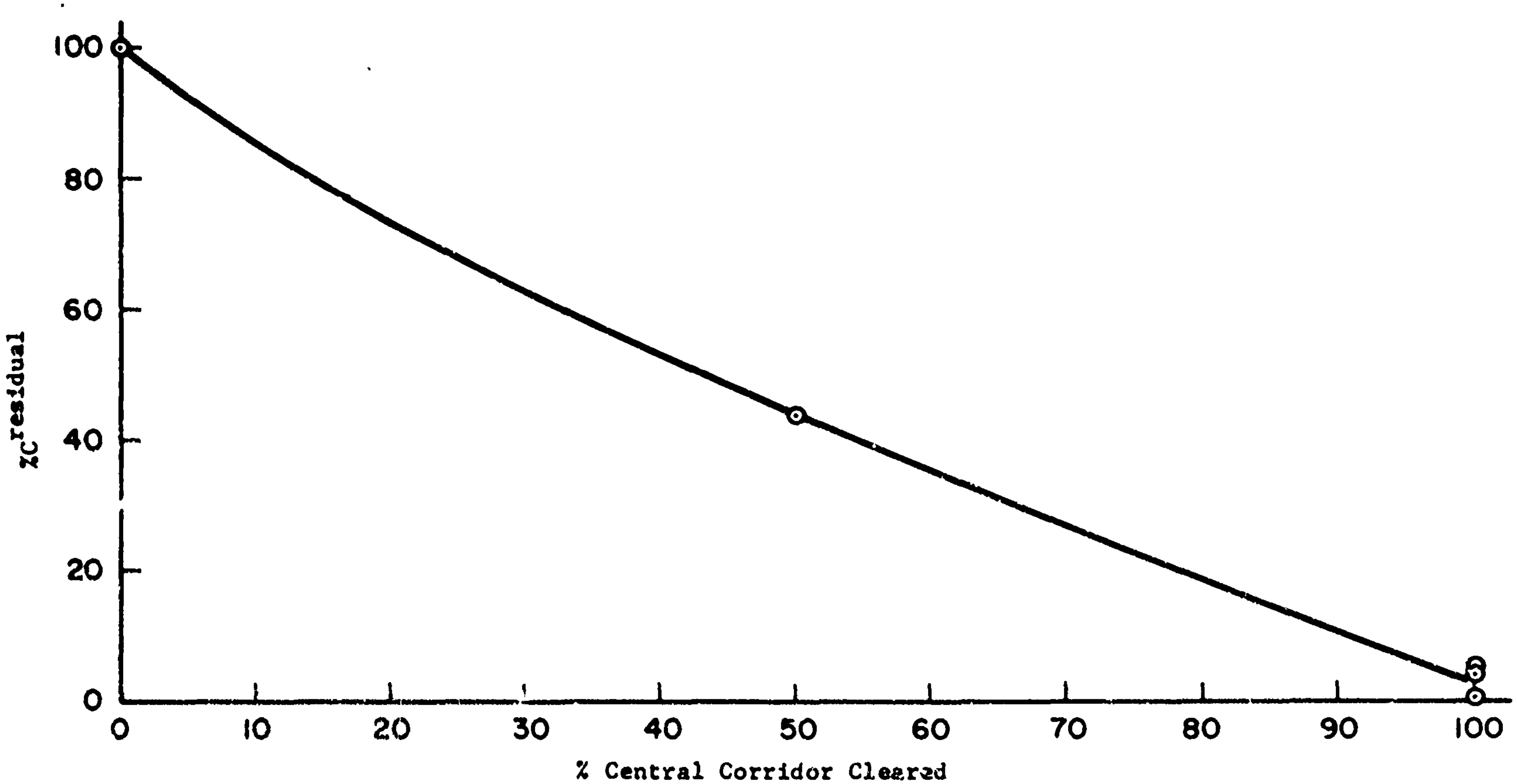

Fig. C-2a. Limited Plane Residual Ground Contribution.
Corridor Width: 0-49 feet.

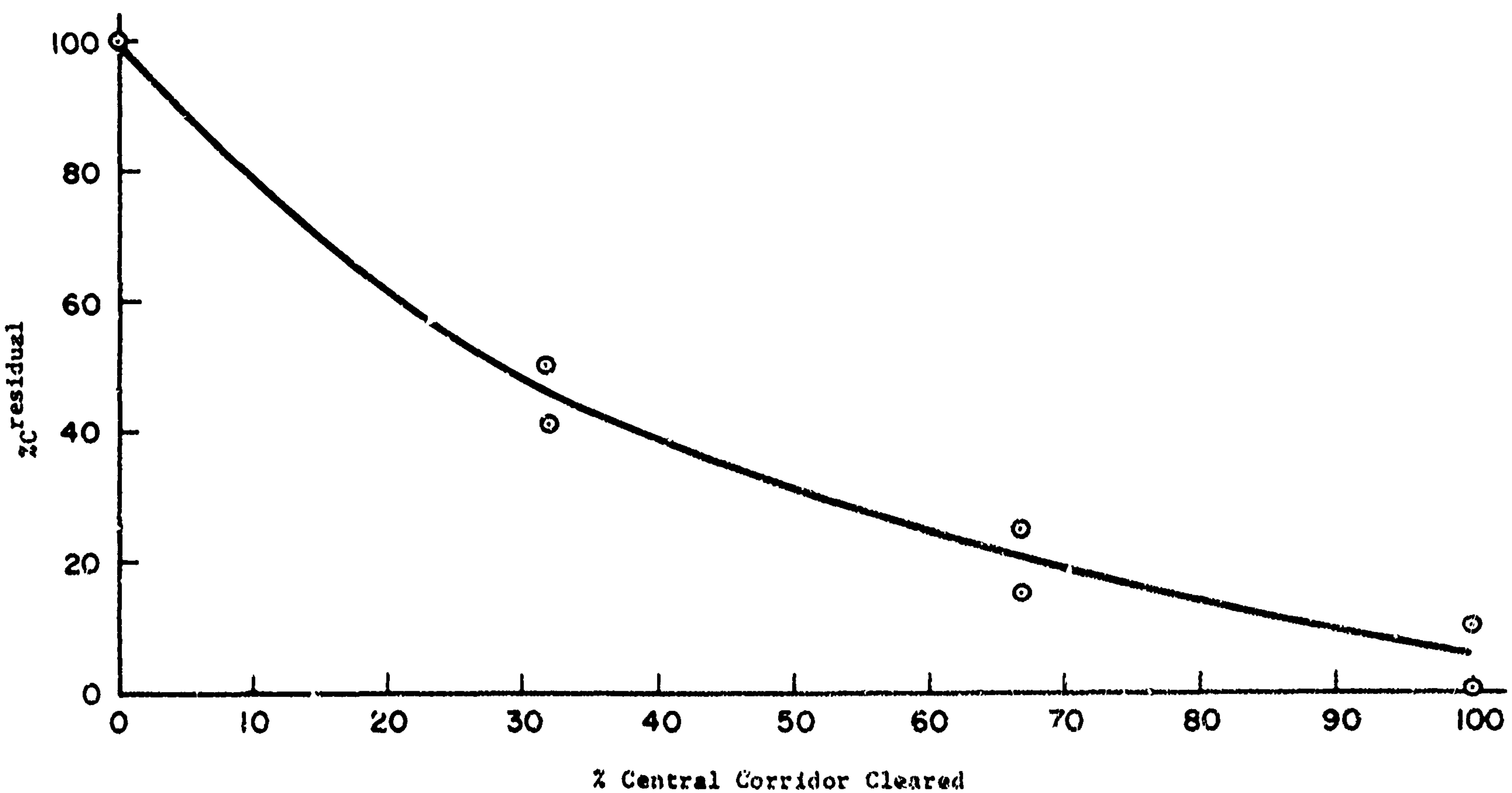

Fig. C-2b. Corridor Width: 50-74 feet.

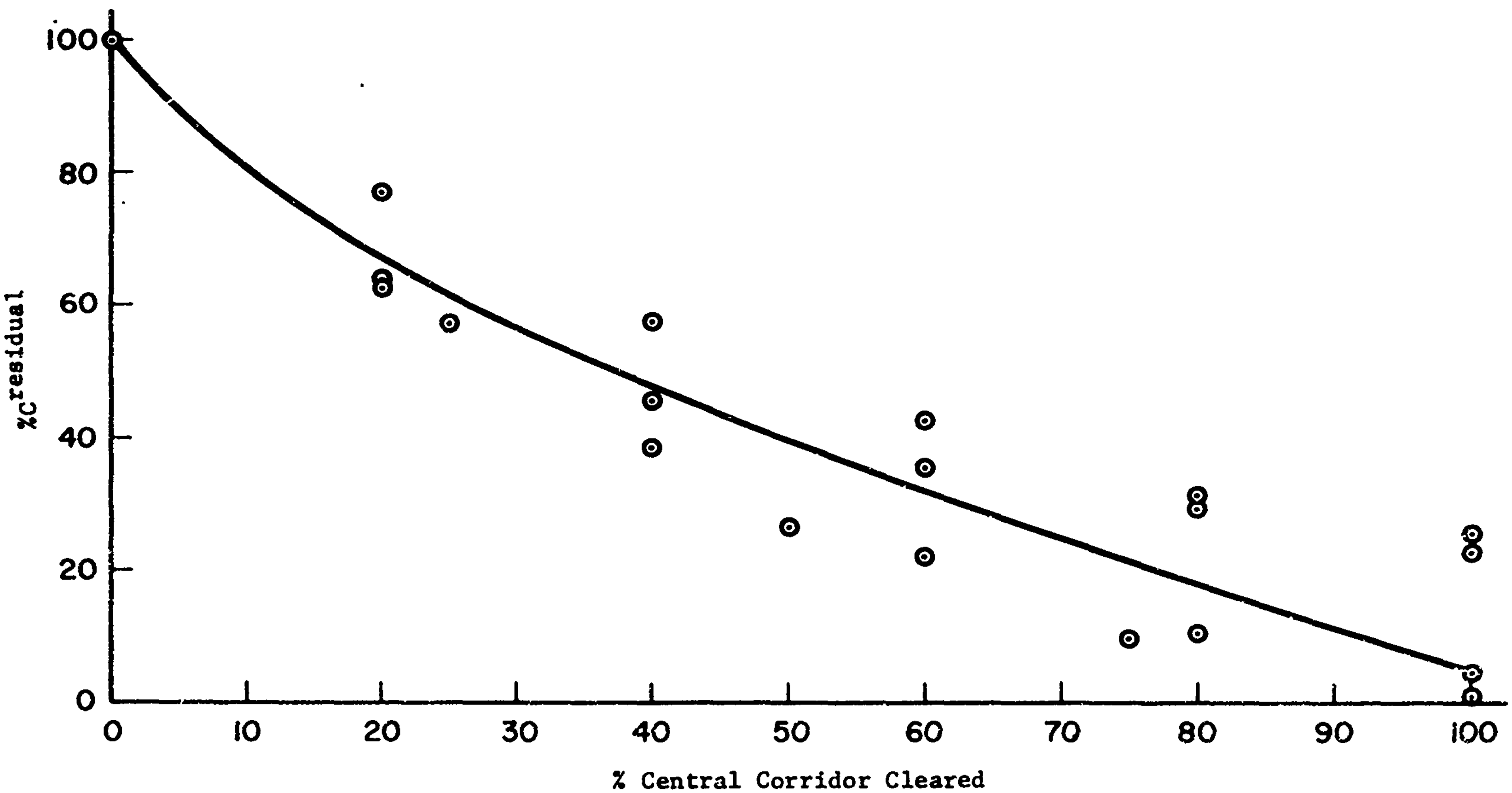

Fig. C-2c. Corridor Width: 75-99 feet.

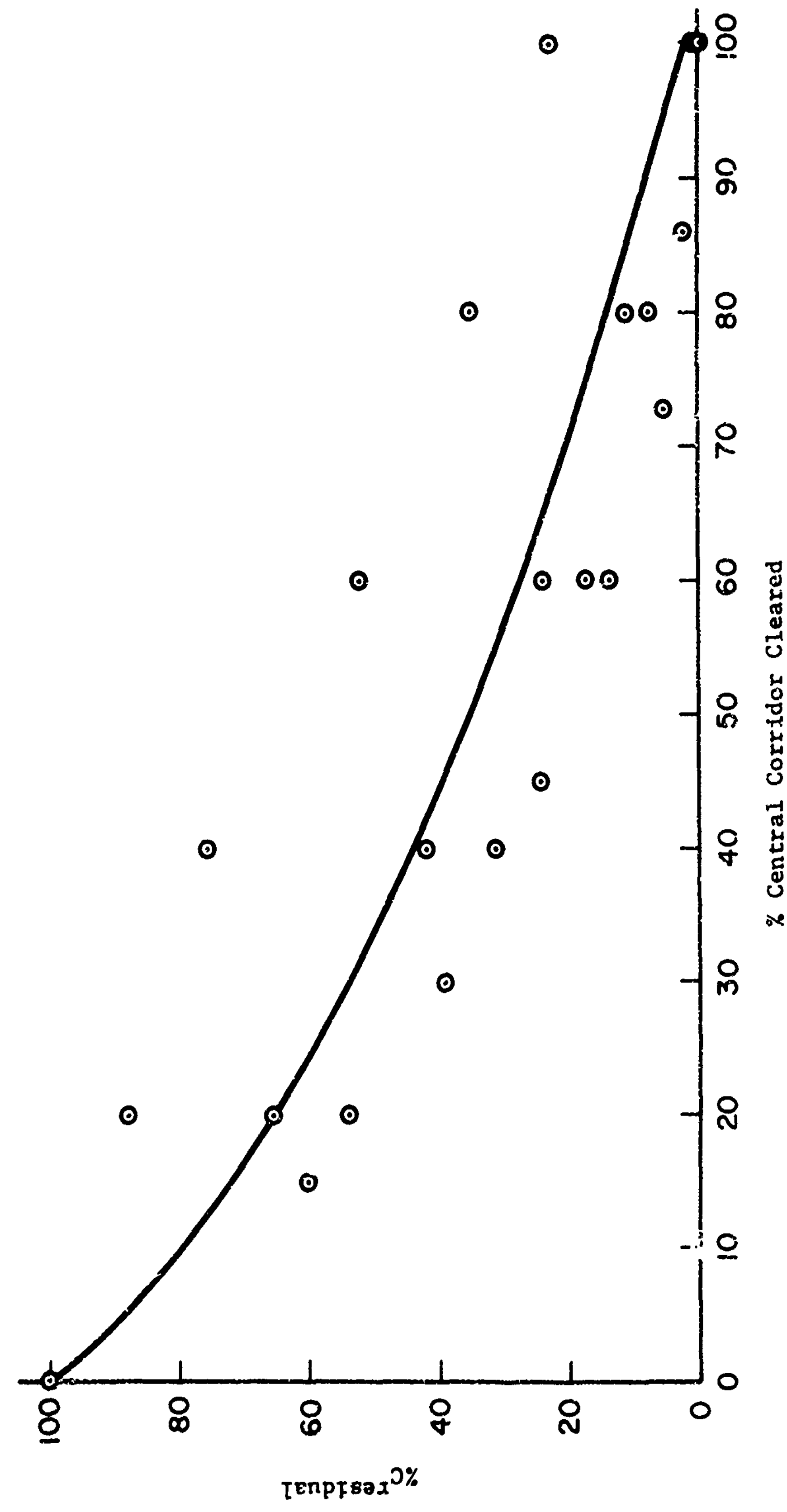

Fig. C-2d. Corridor Width: $\geq$ 100 feet

from the wall is small. The direct contributions are small in such cases a the scatter contributions from the wing corridors are proportionately more signi cant.

Scatter contributions are also more important the higher the floor of th detector story is above the planes of contamination (the floor acts as a barri to direct radiation from close-in source patches). However, the variation in f or height was too large in the Detroit Survey to be subject to meaningful analysis.

C. Special Characteristics Considered in the Analyses

The analyses performed of the facilities in the Detroit Survey consider primarily the effect of limited strip decontamination on dose rate received at particular locations on the first floor. Similar analyses were done for upper floo but the effect of decontamination operations is decreased in these cases since t floor barriers present additional shielding of direct radiation from the limite source external to the building walls. Therefore, maximum effect of limited strip decontamination is always observed at the first floor detector location and this location was chosen for the analyses to reflect maximum parameter sensitivity.

In the analyses, the apertures (doors and windows) in the facilities were not considered in the CONSTRIP V calculations though they were taken into account in PF-COMP to determine the most significant source planes. The exceptions to this arise when essentially an entire wall was found to be of extremely light construction, e.g., a display window at the front of a store. The effect of ignoring apertures in the CONSTRIP calculations is to increase the scattered contribution coming through the wall. The direct contribution in the facility analyses arose from source planes which were shielded by the wall areas below windows, and thus except for doorways, which were of minor consideration, apertures do not affect the direct radiation calculation. Assuming there are no apertures in the wall compensates to some degree for the radiation scattered in and down from walls of the stores above the detector location, and radiation from other miscellaneous sources such as ceiling-shine and skyshine through the overhead mass thickness.*

There are characteristics of some of the limited planes surrounding facilities which merit further discussion. In the case of the United States Public Health Service Hospital, a number of special considerations must be taken into account. The shape of the building may be imagined as a stick-figured man with a wide, flat head.† The two limited planes between the head and arms of the stick-figure man were treated as one plane, with the detector centered in the head of the figure. Because of this detector location, the central portion of one wall is shielded by the neck of the figure. The result of the calculation for this wall is not

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* Skyshine through the wall barrier is accounted for by the build-up factor used in CONSTRIP.

† Cf. Fig. B-2a, page B-6.

included in the figures. It is mentioned here because the result of cleaning of the area directly below the head of the figure, yields a decontamination effectiveness of roughly 77 percent. This indicates the abnormally large importance of the wing areas in the case of a shielding structure adjacent the center of a building part under consideration.

The arms of the stick-figure shape of the USPHS Hospital were also analyzed. These building parts are partially shielded by the head of the figure. The resulting configurations were treated as limited planes extending the entire length of the arm walls, plus offset corridors beyond the edge of the head. For each arm, the limited plane next to the wall extends for approximately 31 feet perpendicular to the wall and along the entire length of the wall, and a corridor of contamination extends for an additional 100 feet beyond the 31 foot width. The analyses can be more easily understood by referring to the plot plan of the facility given in Appendix B of this report. For both arms, the limited plane extending approximately 31 feet from the wall contributes approximately 55 percent of the combined contribution of this plane and the 100 foot corridor beyond. The corridor accounts for the remainder of the contribution through this wall.

The right leg (the one to the right with the figure in an upright position) of the USPHS Hospital facility faces an approximately triangular-shaped, totally enclosed area bounded by the right arm and some other peripheral structures. This potential plane of contamination was treated as two strips each the length of the wall by 20 feet wide and two further 20-foot wide strips narrowing in length to approximate the boundary imposed by the arm of the structure. The left leg of the facility was treated in the identical manner. Clearing these areas of fallout contamination would leave a residual ground contribution of less than 5 percent through the wall barrier to a centrally located detector position.

The rear portions of the right and left arms of the USPHS Hospital face the same triangular areas as was discussed above for the legs of the structure. In addition to this triangular area, there is a potential radiation source from a corridor defined by the peripheral buildings and the end of the structure's leg. Decontaminating only the triangular section of this contaminated field leaves a residual ground contribution through the wall in question of 33 percent of the original contribution.

Other structures also were encountered with special characteristics. Examples are the Hale School, which is built in the shape of a letter "J" with an inward projection from the short leg of the "J," and the Roseville DPW and Water Building, which is built in the shape of a "U." Also, the St. John Hospital has several

projections and alleyways which constitute special considerations for decontamination evaluation.

The St. John Hospital has limited planes which were well defined rectuangular areas, and were easily included in the analyses of limited field contributions given in the figures. The Roseville DPW and Water Building has building parts which are partially shielded by the adjacent other parts of the structure. This causes asymmetries in the contributions from the various wing corridors of the facility, but otherwise causes little complication in the analysis by CONSTRIP. In the case of the Hale School, the "J" shaped area also was easily described in the CONSTRIP Analysis. In all cases where the planes could essentially be considered as limited potential areas of contamination, essentially rectangular in section or subsection, clean up produced results typical of those shown in Figs. C-2a to C-2d.

The special characteristics of these planes and their importance required detailed description for accurate analysis of each facility. It is not the purpose of this investigation to investigate facilities, per se, but only to characterize structures involved according to general and special characteristics. Therefore, the above discussion was made only to point out that this kind of description and analysis is possible through the use of the CONSTRIP V Computer Program. Some of the special characteristics of other facilities included ramps and loading docks. These components require total decontamination for use. The effectiveness of such action is dependent upon the extent of the source plane to which the component is exposed. For limited planes, the results obtained above apply; for infinite planes, general guidelines cannot as yet be given.

D. Summary

Roof sources are generally of first importance in decontamination operations. The analyses of the Detroit Survey Facilities indicate that no generalization as to the effectiveness of limited strip decontamination can as yet be made for facilities adjoined by essentially infinite planes of contamination. For limited planes of contamination, anticipated results of decontamination may be expected to follow the curves faired through the points in Figs. C-2a to C-2d.

As a general rule, it may be stated that for limited planes, the portion of a contaminated field defined by the width of the field and the length of the wall adjoining the field, i.e., the wall adjacent corridor (cf. Fig. 3, page 9) is of paramount importance in decontamination of ground sources. However, when a contaminated field is partially bounded by a mutual shield or natural obstruction to fallout deposition, it is necessary to consider the wing corridors. In these cases the wing corridors may contribute 30 to

50 percent of the total dose rate contribution (consider for instance the special considerations described above for the USPHS Hospital). In any event the best conclusion to be reached for direction of decontamination operations is to concentrate on structures with limited fields of contamination, and, after decontaminating the roof of the structure (if it is within 3 floors of the detector location, to concentrate on cleaning up the corridors adjacent the walls of the building.

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13. ABSTRACT

A discussion is given of analyses utilizing the CONSTRIP V Computer Program performed for the purpose of decontamination operation guideline development. The theoretical calculations are described in summary form and principal results are presented. Also included is a description of a survey of essential facilities in the Detroit area, with an accompanying analyses of these facilities to determine the effectiveness of limited strip decontamination operations.

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Nuclear Physics					10	4

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